UNCONTROLLED

FEDERAL FACILITY AGREEMENT AND CONSENT ORDER (FFACO)
RECORD OF TECHNICAL CHANGE (ROTC)

Corrective Action Unit (CAU) Number: 477
CAU Description: Area 12 N-Tunnel Muckpile
CAU Owner: Defense Threat Reduction Agency (DTRA)

ROTC No. DOE/NV--1367 07-DTRA-009-ROTC 1 **Page** 1 of 8

Document Type Corrective Action Decision Document/Closure Report (CADD/CR) **Date** 01/07/2020

The following technical changes (including justification) are requested by:

Tiffany Gamero
Requestor Name

Long-Term Monitoring Activity Lead
Requestor Title

Description of Change:

1. This ROTC replaces the Use Restriction (UR) information listed in the documentation for CAU 477.

   UR forms have been updated to list all UR requirements, including but not limited to: post-closure site controls (signs, fencing, etc.), inspection and maintenance requirements, and Geographic Information Systems (GIS) coordinate information. The UR requirements and form(s) included in this ROTC represent the current corrective action requirements for each Corrective Action Site (CAS) in this CAU and supersede information concerning corrective action and post-closure requirements in existing documentation.

2. The UR boundary coordinate values were changed due to conversion from North American Datum (NAD) 1927 to NAD 1983.
3. Added the following as a note in each UR: "This CAS is owned by DTRA. Any modification to the UR must be approved by DTRA."

Justification:

1. Some changes in the UR requirements from those found in closure documents have been subsequently modified in letters, memos, and inspection reports. This has resulted in difficulty in determining current post-closure requirements. A review of the post-closure requirements for this CAU has been conducted to ensure that all requirements have been identified and documented on the new UR form. The new UR form was developed to be inclusive of all requirements for long-term monitoring and standardize information contained in the URs consistent with current protocols.

2. UR boundary coordinates need to be in one standardized coordinate system.
3. This statement was added to clarify that the CAS is owned by DTRA even though the use restriction form title states, "U.S. Department of Energy, Environmental Management Nevada Program Use Restriction

FEDERAL FACILITY AGREEMENT AND CONSENT ORDER (FFACO)
RECORD OF TECHNICAL CHANGE (ROTC)

Corrective Action Unit (CAU) Number: 477
CAU Description: Area 12 N-Tunnel Muckpile
CAU Owner: Defense Threat Reduction Agency (DTRA)

ROTC No. DOE/NV--1367 07-DTRA-009-ROTC 1 **Page** 2 of 8

Document Type Corrective Action Decision Document/Closure Report (CADD/CR) **Date** 01/07/2020

Description of Change:

Justification:
Information."

Schedule Impacts:
No impacts to schedule.

ROTC applies to the following document(s):

- Defense Threat Reduction Agency. 2007 (Republished 2010). Corrective Action Decision Document/Closure Report for Corrective Action Unit 477: Area 12 N-Tunnel Muckpile, Nevada Test Site, Nevada, Rev. 0, DOE/NV--1367 07-DTRA-009. Mercury, NV.
- Errata Sheet for CAU 477 CADD/CR (DOE/NV--1367 07-DTRA-009), dated 09/12/2007.

FEDERAL FACILITY AGREEMENT AND CONSENT ORDER (FFACO)
RECORD OF TECHNICAL CHANGE (ROTC)

Corrective Action Unit (CAU) Number: 477
CAU Description: Area 12 N-Tunnel Muckpile
CAU Owner: Defense Threat Reduction Agency (DTRA)

ROTC No. DOE/NV--1367 07-DTRA-009-ROTC 1 **Page** 3 of 8

Document Type Corrective Action Decision Document/Closure Report (CADD/CR) **Date** 01/07/2020

Approvals:

/s/ Tiffany Gamero Date 1/28/2020

Tiffany Gamero
Activity Lead
Environmental Management (EM) Nevada Program

FRAHER.JEFFREY.T.1020435395 Digitally signed by FRAHER.JEFFREY.T.1020435395 Date: 2020.01.27 09:39:50 -07'00' Date

Jeffrey Fraher
Environmental Engineer
Defense Threat Reduction Agency (DTRA)

/s/ Mark McLane for Date 01/30/2020

Christine Andres
Chief, Bureau of Federal Facilities
Nevada Division of Environmental Protection (NDEP)

U.S. Department of Energy, Environmental Management Nevada Program
Use Restriction Information

General Information

Use Restriction (UR) Type(s): FFACO Only

Corrective Action Unit (CAU) Number & Description: 477 - Area 12 N-Tunnel Muckpile

Corrective Action Site (CAS) Number & Description: 12-06-03 - Muckpile

CAU/CAS Owner: DTRA

Note: This CAS is owned by DTRA. Any modification to the UR must be approved by DTRA.

Section I. *Federal Facility Agreement and Consent Order* (FFACO) UR

Basis for FFACO UR

Summary Statement: This FFACO UR is established to protect workers from inadvertent exposure to radiological and chemical contaminants that were released at this site. Chemical contaminants are present that exceed final action levels under the Occasional Use Area (80 hours per year) exposure scenario.

FFACO UR Physical Description

Surveyed Area (UTM, Zone 11, NAD 83, meters):

UR Boundary	UR Point[1]	Easting[2]	Northing[2]
FFACO Boundary	1	572,209	4,117,162
	2	571,838	4,117,164
	3	571,520	4,117,316
	4	571,690	4,117,580
	5	572,217	4,117,420
	6	572,209	4,117,162

[1]UR Points are listed clockwise beginning at the southernmost point. If multiple points share the southernmost Northing coordinate, the easternmost point is listed as Point 1.

[2]UR coordinate values presented herein were transformed from the North American Datum of 1927, and rounded to the nearest meter; resultant coordinates may not reflect the original precision of values contained within the source GIS data set.

Boundary Applies to: Both Surface and Subsurface

U.S. Department of Energy, Environmental Management Nevada Program
Use Restriction Information

Starting Depth: 0 **Ending Depth:** 61

Depth Unit: Centimeters

Survey Source: GPS

FFACO UR Requirements

Site Controls:

This FFACO UR is recorded as described in **Section IV. Recordation Requirements** to restrict activities within the area by the coordinates listed above and depicted in the attached figure without prior notification of NDEP unless the activities are conducted under the provisions of 10 CFR, Part 835, Occupational Radiation Protection and 10 CFR, Part 851, Worker Safety and Health Program.

Control	Criteria
Signage	Present and legible.

Inspection Frequency: Annual

Additional Considerations:

Consideration	Criteria
None	None

Requirements Comments: N/A

Section II. Administrative UR

An Administrative UR is not identified for this site.

Section III. Supporting Documentation

UR Source Document(s)

ROTC 1 for CAU 477 CADD/CR (DOE/NV--1367 07-DTRA-009), dated 01/07/2020.

Errata Sheet for CAU 477 CADD/CR (DOE/NV--1367 07-DTRA-009), dated 09/12/2007.

Defense Threat Reduction Agency. 2007 (Republished 2010). Corrective Action Decision Document/Closure Report for Corrective Action Unit 477: Area 12 N-Tunnel Muckpile, Nevada Test Site, Nevada, Rev. 0, DOE/NV--1367 07-DTRA-009. Mercury, NV.

U.S. Department of Energy, Environmental Management Nevada Program
Use Restriction Information

Attachments

- FFACO UR Boundary Map (UTM, Zone 11, NAD 83 meters)

Section IV. Recordation Requirements

Recordation:

The above UR(s) are recorded in the:

- FFACO Database
- NNSA M&O Contractor GIS
- EM Nevada Program CAU/CAS Files

Section V. DTRA Approval

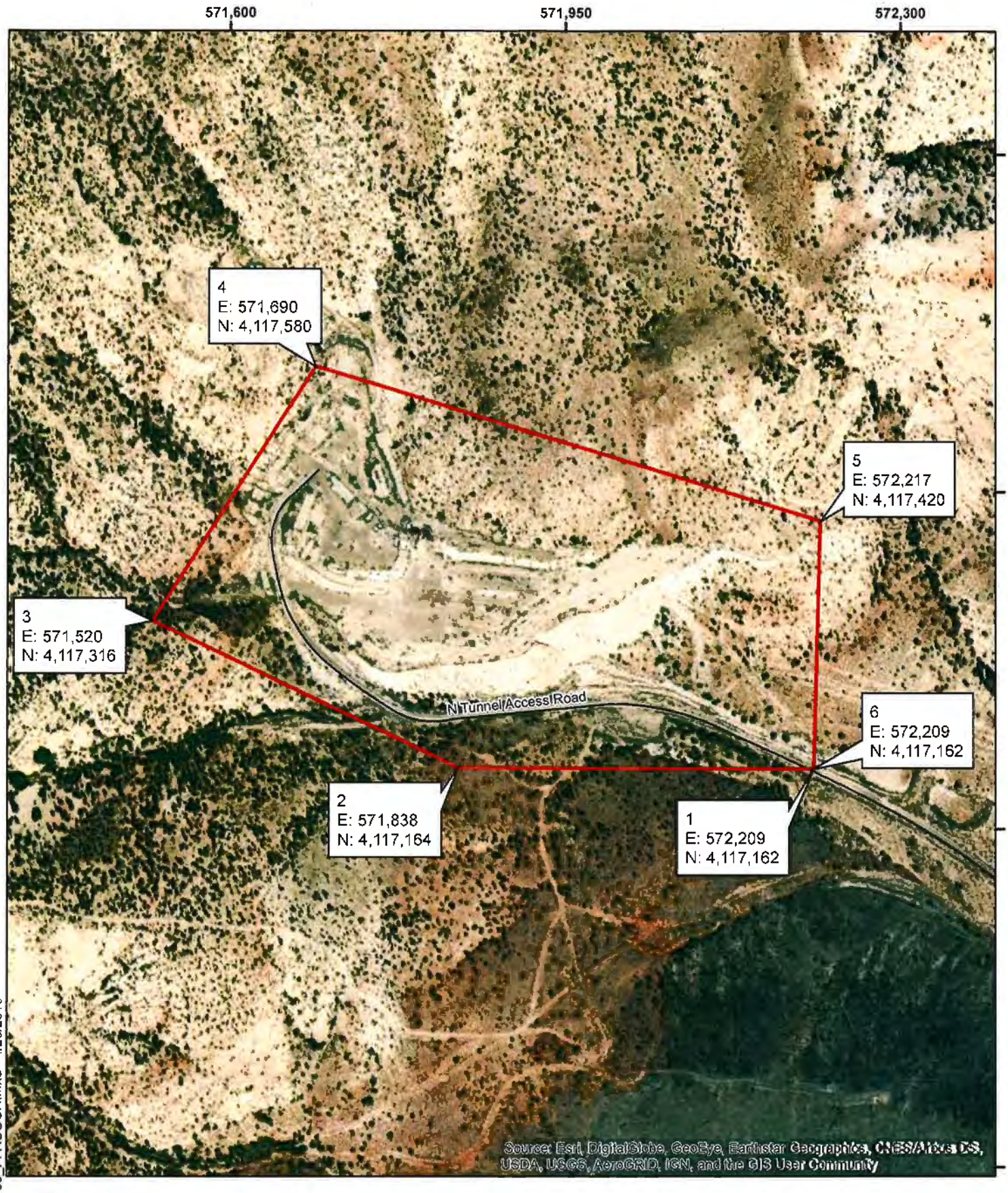
FRAHER.JEFFREY.T.1020435395 Digitally signed by FRAHER.JEFFREY.T.1020435395 Date: 2020.01.27 09:57:58 -07'00'

Date: _____

Jeffrey Fraher

Environmental Engineer

DTRA



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CAU 477, CAS 12-06-03
Muckpile
FFACO UR Boundary

Explanation
- FFACO UR
- Local Road

0 50 100 200 Meters
0 150 300 600 Feet

N

NOTE: Size and location of features are approximated
Coordinate System: NAD 1983 UTM Zone 11N, Meter

Source: Navarro GIS, 2019

Supplemental Information Figure

Additional supplemental information on site features was not present in previous iterations of this Use Restriction (UR), therefore a supplemental information figure is not attached. If additional information on site features is required for this site, please contact the *Federal Facility Agreement and Consent Order* (FFACO) Database Administrator.

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ERRATA SHEET

The Following Corrections and Clarifications Apply to: Corrective Action Decision Document / Closure Report for Corrective Action Unit 477: Area 12 N-Tunnel Muckpile, Nevada Test Site

DOE Document Number: This is a DTRA document and does not have a number.

Revision: 0

Original Document Issuance Date: May 2007

This errata sheet was issued under cover letter from DTRA on: September 12, 2007

In Appendix E, page E-2 under the Surveyed Area heading, there is a northing (N) coordinate and a southing (S) coordinate. All of the S coordinates should be easting (E) coordinates so change all of the Ss to Es for those coordinates.

The northeast corner easting coordinate should be changed from E-579926.13 to E-579296.13

DOE/NV--1367
07-DTRA-009

CORRECTIVE ACTION DECISION DOCUMENT/CLOSURE REPORT FOR CORRECTIVE ACTION UNIT 477: AREA 12 N-TUNNEL MUCKPILE, NEVADA TEST SITE

Controlled Copy No: **UNCONTROLLED**

Revision No.: 0

May 2007
(Republished March 2010)

DISCLAIMER

CORRECTIVE ACTION DECISION DOCUMENT/CLOSURE REPORT FOR CORRECTIVE ACTION UNIT 477: AREA 12 N-TUNNEL MUCKPILE, NEVADA TEST SITE

Prepared by
Defense Threat Reduction Agency
Mercury, Nevada

Controlled Copy No. ___ UNCONTROLLED

Revision No.: 0

May 2007
(Republished March 2010)

CORRECTIVE ACTION DECISION
DOCUMENT/CLOSURE REPORT
FOR CORRECTIVE ACTION UNIT 477:
AREA 12 N-TUNNEL MUCKPILE,
NEVADA TEST SITE

Approved by: /s/David C. Loewer for Tiffany A. Lantow Date: 5/14/2007

Tiffany A. Lantow
Environmental Program Manager
Nevada Operations Office
Defense Threat Reduction Agency

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List of Acronyms and Abbreviations

ASTM	American Society for Testing and Materials
bgs	Below ground surface
BN	Bechtel Nevada
CADD	Corrective Action Decision Document
CAI	Corrective Action Investigation
CAIP	Corrective Action Investigation Plan
CAS	Corrective Action Site
CAU	Corrective Action Unit
CLP	Contract Laboratory Program
Co	Cobalt
COC	Contaminant of concern
COPC	Contaminant of potential concern
CR	Closure Report
Cs	Cesium
CSM	Conceptual site model
DOE	U.S. Department of Energy
DQA	Data quality assessment
DQI	Data quality indicator
DQO	Data quality objective
DRO	Diesel-range organics
DTRA	Defense Threat Reduction Agency
EPA	U.S. Environmental Protection Agency
FAL	Final action level
FFACO	*Federal Facility Agreement and Consent Order*
ft	Foot

List of Acronyms and Abbreviations (continued)

ICP	Inductively coupled plasma
LCS	Laboratory control sample
MCC	Maximum concentration of contamination
mg/kg	Milligrams per kilogram
mrem/yr	Millirem per year
MS	Matrix spike
MSD	Matrix spike duplicate
N/A	Not applicable
NAC	*Nevada Administrative Code*
ND	Nondetect
NDEP	Nevada Division of Environmental Protection
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
ns	Not sampled
nsu	Not surveyed
NTS	Nevada Test Site
PAL	Preliminary action level
Pb	Lead
pCi/g	Picocuries per gram
POC	Performance Objective for the Certification of Nonradioactive Hazardous Waste
PRG	Preliminary remediation goal
Pu	Plutonium
QA	Quality assurance
QAPP	Quality Assurance Project Plan

List of Acronyms and Abbreviations *(continued)*

QC	Quality control
RCRA	*Resource Conservation and Recovery Act*
RESRAD	Residual Radioactive
RPD	Relative percent difference
RT	Regulatory threshold
SDG	Sample delivery group
SSHASP	Site-Specific Health and Safety Plan
SSTL	Site-specific target level
SVOC	Semivolatile organic compound
TCLP	Toxicity Characteristic Leaching Procedure
TPH	Total petroleum hydrocarbon
VOC	Volatile organic compound
yd^3	Cubic yard
µg/kg	Micrograms per kilogram
µg/L	Micrograms per liter
%R	Percent recovery

Executive Summary

This Corrective Action Decision Document (CADD)/Closure Report (CR) was prepared by the Defense Threat Reduction Agency (DTRA) for Corrective Action Unit (CAU) 477, N-Tunnel Muckpile. This CADD/CR is consistent with the requirements of the *Federal Facility Agreement and Consent Order* (FFACO) agreed to by the State of Nevada, the U.S. Department of Energy, and the U.S. Department of Defense. Corrective Action Unit 477 is comprised of one Corrective Action Site (CAS):

- 12-06-03, Muckpile

The purpose of this CADD/CR is to provide justification and documentation supporting the recommendation for closure with no further action, by placing use restrictions on CAU 477. To support this recommendation, a corrective action investigation (CAI) was performed in March and April 1999. The purpose of the CAI was to fulfill the following data needs as defined during the Data Quality Objective (DQO) process:

- Determine whether the muckpile contents are hazardous under the *Resource Conservation and Recovery Act*, contain total petroleum hydrocarbons (TPH) contamination at levels exceeding the *Nevada Administrative Code* (NAC) limits, or contain contamination exceeding background levels.
- If contaminants of concern (COCs) are present, determine what further action will be needed.

The CAU 477 dataset from the CAI was evaluated based on the data quality indicator parameters. This evaluation demonstrated the quality and acceptability of the dataset for use in fulfilling the DQO data needs.

Analytes detected during the CAI were evaluated against final action levels (FALs) established in this document. Tier 2 FALS were determined for the hazardous constituents of TPH-diesel-range organics (DRO) and the radionuclide cesium-137. The Tier 2 FALs were calculated for the radionuclides using site-specific information. The hazardous constituents of TPH-DRO were compared to the preliminary action levels (PALs) defined in the Corrective Action Investigation Plan (CAIP), and because none of the PALs were exceeded, the PALs became the FALs. The radionuclide FALs were calculated using the Residual Radioactive (RESRAD) code (version 6.21) for the remote reuse scenario. The RESRAD calculation determined the activities of all radionuclides that together would sum to an exposure dose of 25 millirem per year to a site

receptor (based on their relative abundance at the site). Based on the field investigation, none of the contaminants were determined to be present at concentrations exceeding their corresponding FALs.

Based on the data and risk evaluations, the DQO data needs presented in the CAIP were met, and the data accurately represent the radiological and chemical risk present at CAU 477. Based on the results of the CAI data evaluation, it was determined that closure in place with use restrictions is the appropriate corrective action for CAU 477 and that use restrictions will effectively control exposure to future land users. This is based on the fact that even though the FAL was exceeded in one sample, this remote, controlled access site poses only limited risk overall to public health and the environment. Therefore, DTRA provides the following recommendations:

- Close one COC in place at CAU 477 with use restriction.
- No further action for CAU 477.
- A Notice of Completion be issued to DTRA by the Nevada Division of Environmental Protection for closure of CAU 477.
- Move CAU 477 from Appendix III to Appendix IV of the FFACO.

1.0 Introduction

This Corrective Action Decision Document (CADD)/Closure Report (CR) has been prepared for Corrective Action Unit (CAU) 477, N-Tunnel Muckpile, Nevada Test Site (NTS). The corrective action proposed in this document complies with the *Federal Facility Agreement and Consent Order* (FFACO) that was agreed to by the State of Nevada, U.S. Department of Energy (DOE), and the U.S. Department of Defense (FFACO, 1996).

The N-Tunnel Muckpile is identified under FFACO classification as CAU 477, Area 12, U12 N-Tunnel Muckpile. The CAU consists of one Corrective Action Site (CAS): 12-06-03. The N-Tunnel Muckpile is located approximately 42 miles north of Mercury in Area 12 of the NTS (Figure 1-1).

This CADD/CR describes the corrective action that is selected as a result of the investigation activities and the rationale for its selection. The rationale consists of a justification for closure in place with use restrictions in accordance with Sections IV.8 and IV.11 of the FFACO (1996).

1.1 Purpose

The purpose of this CADD/CR is to provide justification for the closure of CAU 477 with use restrictions but no further action based on the results of the Corrective Action Investigation (CAI). The CAI was conducted in accordance with the *Corrective Action Investigation Plan* (CAIP) *for Corrective Action Unit 477: N-Tunnel Muckpile, Nevada Test Site* (DTRA, 1999), which provides additional information relating to the history, planning, and scope of the investigation.

N-Tunnel was used for 21 nuclear weapons effects tests between 1967 and 1992, and one high explosive test in 1993. The muckpile consists of 296,300 cubic yards (yd^3) of material mined from the N-Tunnel during initial construction and re-entry operations following tests.

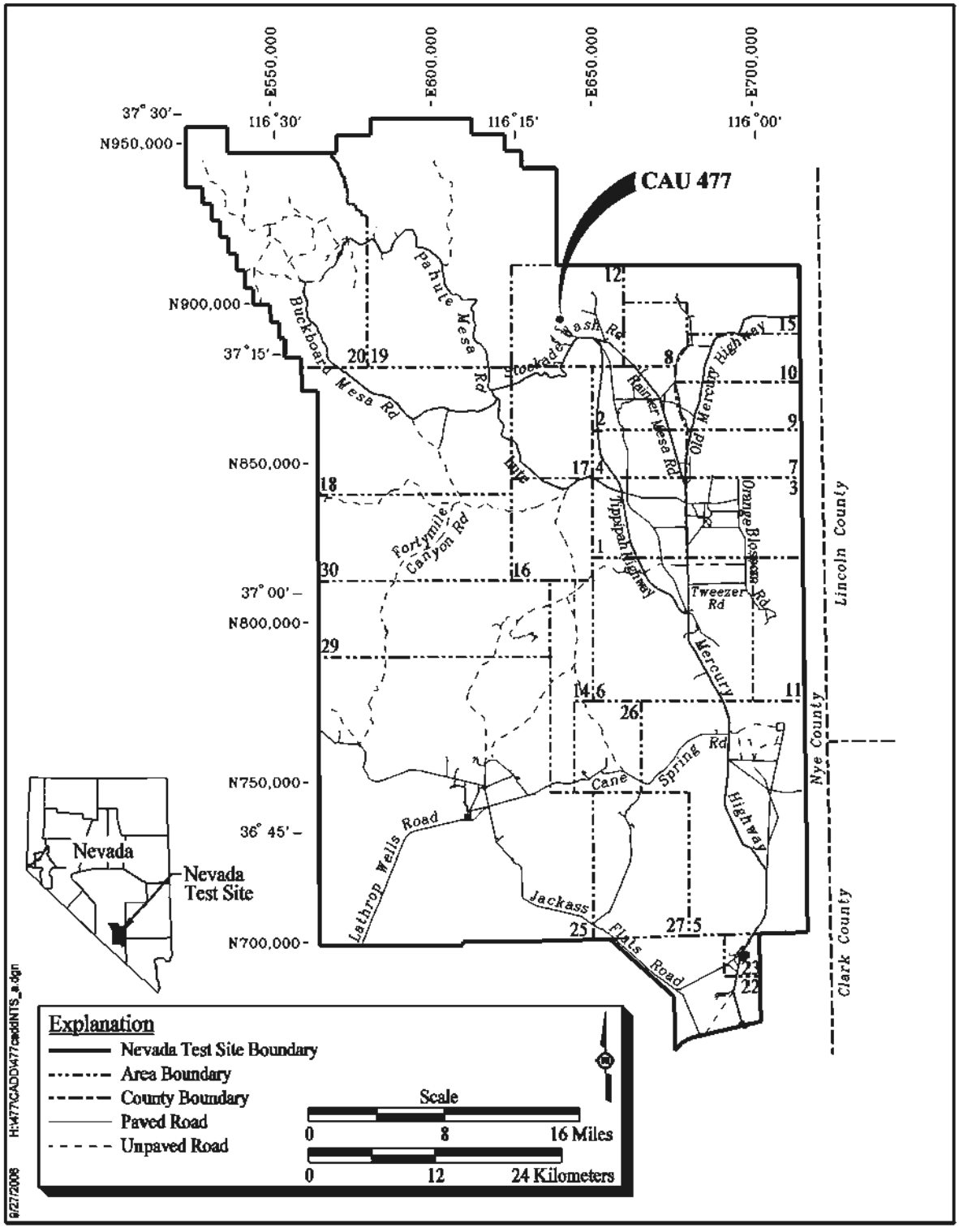

Figure 1-1
N-Tunnel Muckpile Location Map, Area 12, Nevada Test Site

1.2 Scope

The scope of this CADD/CR is to justify and recommend that no further action is required at CAU 477, Area 12 N-Tunnel Muckpile. To achieve this scope, the following actions were implemented:

- Evaluation of current site conditions, including the nature and extent of contaminants of concern (COCs).
- Closure in place with use restrictions to prevent exposure of industrial and construction workers to unacceptable risks.

1.3 CADD/CR Contents

This CADD/CR is divided into the following sections:

- Section 1.0 – Introduction: Summarizes the purpose, scope, and contents of this CADD/CR.
- Section 2.0 – CAI Summary: Summarizes the investigation field activities, the results of the investigation, and the data quality objective (DQO) assessment.
- Section 3.0 – Recommendation: States why no further action is required.
- Section 4.0 – References: Lists all documents referenced in the CADD/CR.
- Appendix A: Corrective Action Investigation Report for CAU 477, Area 12 N-Tunnel Muckpile, NTS
- Appendix B: Data Quality Objectives Process for CAU 477, Area 12 N-Tunnel Muckpile
- Appendix C: Data Assessment
- Appendix D: Risk Assessment for CAU 477
- Appendix E: Closure Summary

All work was performed in accordance with the following documents:

- *Corrective Action Investigation Plan for Corrective Action Unit 477: N-Tunnel Muckpile, Nevada Test Site*, Rev. 1 (DTRA, 1999)

- *Industrial Sites Quality Assurance Project Plan* (QAPP), Rev. 0 (DOE/NV, 1996)
- *Federal Facility Agreement and Consent Order* (FFACO, 1996)

The DQOs identified in the CAIP are as follows:

- Determine whether the muckpile contents are hazardous under the *Resource Conservation and Recovery Act* (RCRA), contain total petroleum hydrocarbons (TPH) contamination at levels exceeding the *Nevada Administrative Code* (NAC) limits, or contain contamination exceeding background levels.
- If COCs are present, determine what further action will be needed.

The data quality indicators (DQIs) as defined in the Industrial Sites QAPP (NNSA/NV, 2002) were achieved and the DQOs established in the CAIP were met. The 2002 QAPP superseded the 1996 QAPP so it was used for assessing the DQIs for the site.

Subsequent to approval of the CAIP and completion of the CAI, the Nevada Division of Environment Protection (NDEP) approved a risk-based approach for developing final action levels (FALs) to evaluate contaminant concentrations.

2.0 Corrective Action Investigation Summary

The following sections describe and summarize the results of the CAI activities conducted at CAU 477. For detailed CAI results, refer to Appendix A.

2.1 Investigation Activities

From March 15 through April 27, 1999, CAI activities were performed at the N-Tunnel Muckpile as set forth in the CAIP (DTRA, 1999). The purpose of the CAI was to determine whether or not the N-Tunnel Muckpile and/or the underlying native soils are hazardous under RCRA, and to provide sufficient information and data to develop appropriate corrective action strategies for the muckpile. As outlined in the CAIP (DTRA, 1999), the following tasks were performed:

- **Sampling of the muckpile contents and underlying native soils (>5 ft)** – Thirty-seven boreholes were drilled to characterize the subsurface of the muckpile (greater than 5 feet [ft]). This includes the muckpile contents, the buried retention pond sediments, and the native soil beneath the muckpile. A continuous core was extracted from each borehole from which a total of 75 samples were submitted for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), RCRA metals, TPH, and radionuclide analysis.

- **Surface/shallow subsurface sampling (0 to 5 ft)** – Thirteen boreholes were drilled to characterize the surface/shallow subsurface of the muckpile (less than 5 ft) and 13 samples were collected and submitted for VOCs, SVOCs, RCRA metals, TPH, and radionuclide analysis.

- **Background sampling** –Three locations were identified and hand augered to a depth of 6 to 12 inches to collect background native soil samples. Samples were field screened and submitted for radionuclide and RCRA metals analysis.

The conceptual site model (CSM) postulated that the majority of the muckpile does not contain contaminants of potential concern (COPCs) (less than 1 percent), and if any COPCs are present, they are probably isolated. The areas most likely to be affected are the areas where petroleum compounds were used for tunnel equipment maintenance activities, possibly resulting in releases to the surface and shallow subsurface (0 to 5 ft) soils. The potential also exists for the presence of radionuclides randomly located throughout the muckpile as a result of re-entry operations following a test. These releases, if present, were anticipated to have limited lateral and vertical extent. The CSM also stated that it is possible, but unlikely, that the native soil beneath the muckpile has been impacted by downward migration of COPCs. The results of the CAI showed that there is localized contamination with lead in the N-Tunnel Muckpile. A single sample had a

concentration exceeding the regulatory limit for lead. No other chemical or radionuclide COPCs exceeded action levels in the muckpile. The CAI also demonstrated that no contaminants are leaching into the native materials below the muckpile. Based on these facts, the CSM was shown to be valid.

2.2 Results

The following is a summary of the data obtained during the CAI.

2.2.1 Summary of Analytical Data

The CAI analytical results (Appendix A) indicate the following:

- No VOCs or SVOCs were detected in any of the samples collected during this investigation at concentrations that exceeded the action levels outlined in the CAIP (DTRA, 1999).
- Total petroleum hydrocarbon-diesel-range organics (DRO) were detected in two samples from the muckpile in a concentration that exceeded the action level of 100 milligrams/kilogram (mg/kg) (NAC, 2003b); however, none of the hazardous constituents of TPH-DRO exceeded their Tier 2 action levels, so TPH-DRO is not a COC.
- Lead was detected above the PAL of 800 mg/kg in one near surface sample and it also exceeded the FAL, so lead was determined to be a COC.
- Radionuclide results were compared to soil samples taken from undisturbed locations in the western and southwestern United States and to the screening levels of the *Nevada Test Site Performance Objective for the Certification of Nonradioactive Hazardous Waste* (POC) (BN, 1995). Cesium (Cs)-137 exceeded the PALs in one biased sample; however, a FAL was calculated using the Residual Radioactive (RESRAD) code for the remote reuse scenario, and Cs-137 did not exceed the FAL. Lead (Pb)-212 also exceeded the PAL in one sample; however, it is a short-lived radionuclide (less than 6 months), so a FAL was not calculated using the RESRAD code.
- There were no chemical or radiological constituents detected in the soil below the muckpile at concentrations that exceeded the action levels.

Based on these results, the nature and extent of contamination at CAU 477 has been adequately characterized.

2.2.1.1 Muckpile (CAS 12-06-03)

None of the chemical constituents were detected above the PALs, so the PALs were identified as the FALs for those constituents. The maximum concentration of each detected chemical contaminant at this CAS is listed in Table 2-1. A discussion of the constituents that exceeded the FAL is provided in Appendix D.

Table 2-1
Maximum Reported Chemical Values for CAS 12-06-03 Muckpile
(Page 1 of 2)

Contaminant	Result (mg/kg)	Sample No	Depth (ft bgs)	Final Action Level (mg/kg)
1,2,4-Trimethylbenzene	0.18	NS-40-7	6-7	170
1,3,5-Trimethylbenzene	0.059	NS-40-7	6-7	70
2-Butanone	0.025	NS-50-10	9.5-10.5	110,000
2-Methylnaphthalene	13	NS-40-7	6-7	190
Acetone	0.18	NS-02-19	18.5-19.5	54,000
Arsenic	**38.8**	NS-23-02	**1.5-2.5**	**23**
Barium	5,300	NS-S1-01	0.5-1.5	67,000
Bis(2-ethylhexyl)phthalate	0.85	NS-35-19	18.5-19.5	120
Cadmium	0.46	NS-02-19	18.5-19.5	450
Carbon Tetrachloride	0.002	NS-40-19	18.5-19.5	0.55
Chloroform	0.0018	NS-40-19	18.5-19.5	0.47
Chloromethane	0.0051	NS-15-16	15.5-16.5	160
Chromium	32	NS-02-19	18.5-19.5	450
Diesel-Range Organics	**3,300**	NS-40-7	**6-7**	**100**
Dimethyl Phthalate	2.5	NS-40-7	6-7	100,000
Ethylbenzene	0.0064	NS-40-7	6-7	400
Gasoline	0.68	NS-40-7	6-7	100
Isopropylbenzene	0.0072	NS-40-7	6-7	2,000
Lead	**59,700**	NS-23-02	**1.5-2.5**	**800**
M+P-Xylene	0.035	NS-40-7	6-7	210
Mercury	0.29	NS-16-10	9-11	310
Methylene Chloride	0.011	NS-40-7	6-7	21
Naphthalene	7	NS-40-7	6-7	190
N-Butylbenzene	0.02	NS-40-7	6-7	240
N-Propylbenzene	0.015	NS-40-7	6-7	240
O-Xylene	0.025	NS-40-7	6-7	210

Table 2-1
Maximum Reported Chemical Values for CAS 12-06-03 Muckpile
(Page 2 of 2)

Contaminant	Result (mg/kg)	Sample No	Depth (ft bgs)	Final Action Level (mg/kg)
P-Isopropyltoluene	0.079	NS-02-19	18.5-19.5	2,000
Pyrene	4.3	NS-40-7	6-7	29,000
Sec-Butylbenzene	0.015	NS-40-7	6-7	220
Selenium	1.2	NS-S8-02	1.5-2.5	5,100
Silver	1.1	NS-23-02	1.5-2.5	5,100
Toluene	0.0017	NS-40-7	6-7	520
Trichloroethene	0.0012	NS-40-19	18.5-19.5	0.11

ft bgs = Feet below ground surface
mg/kg = Milligrams per kilogram

No radionuclides were detected at concentrations above the FAL. The maximum concentration of each detected radiological contaminant at this CAS is listed in Table 2-2.

Table 2-2
Maximum Reported Radiological Values for CAS 12-06-03 Muckpile

Contaminant	Result (pCi/g)	Sample No	Depth (ft bgs)	Final Action Level (pCi/g)
Actinium-228	2.67	NS-26-64	63.5-64.5	15 [1]
Bismuth-212	3.8	NS-S7-01	0.5-1.5	5 [1]
Bismuth-214	1.86	NS-16-10	9-11	15 [1]
Cobalt-60	0.73	NS-46-13.5	13.5-14.5	3.8E+07 [2]
Cesium-137	1,340	NS-46-13.5	13.5-14.5	9.0E+11 [2]
Lead-212	3.1	NS-26-64	63.5-64.5	15 [1]
Lead-214	2.36	NS-16-10	9-11	15 [1]
Plutonium-238	0.272	NS-46-13.5	13.5-14.5	9.3E+08 [2]
Plutonium-239	0.55	NS-46-13.5	13.5-14.5	5.2E+11 [2]
Thallium-208	0.93	NS-26-64	63.5-64.5	15 [1]

[1] FAL based on background or the National Council of Radiation Protection and Measurement Report No. 129 recommended screening limits for construction, commercial, and industrial land use scenario (NCRP, 1999) scaled from 25- to 15-millirem-per-year dose and the generic guidelines for residual concentration of radionuclides in DOE Order 5400.5 (DOE, 1993).
[2] FAL based on RESRAD calculation for remote use scenario.

ft bgs = Feet below ground surface
pCi/g = Picocuries per gram

2.2.1.2 N-Tunnel Native (CAS 12-06-03)

None of the chemical constituents found in the native material exceeded the PALs as identified in the CAIP (DTRA, 1999), so the PALs are identified as the FALs. The maximum concentration of each detected chemical contaminant found in the native material at this CAS is listed in Table 2-3.

Table 2-3
Maximum Reported Chemical Values for CAS 12-06-03 Native

Contaminant	Result (mg/kg)	Sample No	Depth (ft bgs)	Final Action Level (mg/kg)
1,2-Dibromo-3-Chloropropane	0.0021	NS-15-24	23-24	2
1,2-Dichlorobenzene	0.001	NS-15-24	23-24	370
2-Butanone	0.024	NS-F-95	94-95	110,000
Acetone	0.032	NS-16-72	71-72	54,000
Arsenic	6.6	NS-20-31	30.5-31.5	23
Barium	4,610	NS-C-94	93.5-94.5	67,000
Benzo(g,h,i)perylene	0.14	NS-37-29	28-29	29,000
Bis(2-ethylhexyl)phthalate	0.22	NS-40-50	49-50	120
Cadmium	0.09	NS-C-94	93.5-94.5	450
Chlorobenzene	0.00069	NS-17-40	39-40	530
Chromium	8.6	NS-39-28	27-28	450
Diesel-Range Organics	48	NS-C-94	93.5-94.5	100
Dimethyl phthalate	0.1	NS-40-50	49-50	100,000
Ethylbenzene	0.001	NS-B-95	94-95	400
Lead	44.1	NS-23-05	5-5.5	800
M+P-Xylene	0.003	NS-B-95	94-95	210
Mercury	0.8	NS-46-85	84-85	310
Methylene Chloride	0.0092	NS-39-28	27-28	21
Naphthalene	0.0058	NS-13-89	88.5-89.5	190
P-Isopropyltoluene	0.00092	NS-15-24	23-24	2,000
Selenium	0.41	NS-B-95	94-95	5,100
Silver	1.3	NS-48-47	46.5-47.5	5,100
Styrene	0.0011	NS-B-95	94-95	1,700
Tert-butylbenzene	0.00083	NS-15-24	23-24	390
Toluene	0.00078	NS-17-40	39-40	520
Trichloroethene	0.00083	NS-17-40	39-40	0.11

ft bgs = Feet below ground surface
mg/kg = Milligrams per kilogram

None of the radionuclides found in the native material under the muckpile exceeded the PALs as defined in the CAIP (DTRA, 1999) except for Pb-212, so the PALs for those radionuclides are identified as the FALs. The Pb-212 is a short-lived (less than 6 months), naturally occurring radionuclide, so a FAL was not calculated with RESRAD. The fact that it is naturally occurring and very short lived makes it not a concern. The maximum concentration of each detected radionuclide found in the native material at this CAS is listed in Table 2-4.

Table 2-4
Maximum Reported Radiological Values for CAS 12-06-03 Native

Contaminant	Result (pCi/g)	Sample No	Depth (ft bgs)	Final Action Level (pCi/g) [1]
Actinium-228	3.18	NS-04-20	19-20	15
Bismuth-212	4.3	NS-04-20	19-20	15
Bismuth-214	4.88	NS-20-31	30.5-31.5	15
Cesium-137	1.54	NS-10-100	99.5-100.5	12.5
Lead-212	**31.3**	NS-23-05	5-5.5	15
Lead-214	6.9	NS-23-05	5-5.5	15
Thallium-208	1.04	NS-04-20	19-20	15

[1] FAL based on background or the National Council of Radiation Protection and Measurement Report No. 129 recommended screening limits for construction, commercial, and industrial land use scenario (NCRP, 1999) scaled from 25- to 15-millirem-per-year dose and the generic guidelines for residual concentration of radionuclides in DOE Order 5400.5 (DOE, 1993).

ft bgs = Feet below ground surface
pCi/g = Picocuries per gram

2.2.1.3 N-Tunnel Background (CAS 12-06-03)

Table 2-5 shows the maximum concentration of chemical constituents found in the background samples. Table 2-6 shows the maximum concentration of radionuclides found in the background samples.

Table 2-5
Maximum Reported Chemical Values for CAS 12-06-03 Background
(Page 1 of 2)

Contaminant	Result (mg/kg)	Sample No	Depth (ft bgs)	Final Action Level (mg/kg) [1]
Arsenic	6.5	NS-B1-0.5	0.5-1.0	23
Barium	156	NS-B3-0.5	0.5-1.0	67,000
Cadmium	0.06	NS-B1-0.5	0.5-1.0	450
Chromium	5.5	NS-B2-0.5	0.5-1.0	450
Lead	23	NS-B1-0.5	0.5-1.0	800

Table 2-5
Maximum Reported Chemical Values for CAS 12-06-03 Background
(Page 2 of 2)

Contaminant	Result (mg/kg)	Sample No	Depth (ft bgs)	Final Action Level (mg/kg) [1]
Mercury	0.04	NS-B3-0.5	0.5-1.0	310
Selenium	0.59	NS-B2-0.5	0.5-1.0	5,100

[1] FAL based on U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goals.

ft bgs = Feet below ground surface
pCi/g = Picocuries per gram

Table 2-6
Maximum Reported Radiological Values for CAS 12-06-03 Background

Contaminant	Result (pCi/g)	Sample No	Depth (ft bgs)	Final Action Level (pCi/g) [1]
Actinium-228	3.4	NS-B3-0.5	0.5-1.0	5
Bismuth-212	2.7	NS-B1-0.5	0.5-1.0	5
Bismuth-214	1.58	NS-B1-0.5	0.5-1.0	5
Cesium-137	1.07	NS-B1-0.5	0.5-1.0	12.5
Lead-212	3.33	NS-B3-0.5	0.5-1.0	5
Lead-214	1.67	NS-B1-0.5	0.5-1.0	5
Thallium-208	1.19	NS-B1-0.5	0.5-1.0	5

[1] FAL based on background or the National Council of Radiation Protection and Measurement Report No. 129 recommended screening limits for construction, commercial, and industrial land use scenario (NCRP, 1999) scaled from 25- to 15-millirem-per-year dose and the generic guidelines for residual concentration of radionuclides in DOE Order 5400.5 (DOE, 1993).

ft bgs = Feet below ground surface
pCi/g = Picocuries per gram

2.2.2 Data Assessment Summary

The data quality assessment (DQA) is presented in Appendix C and includes an evaluation of the DQIs to determine the degree of acceptability and usability of the reported data in the decision-making process. The DQO process ensures that the right type, quality, and quantity of data are available to support the resolution of those decisions at an appropriate level of confidence. Using both the DQO and DQA processes helps ensure that DQO decisions are sound and defensible.

The DQA process as presented in Appendix C is comprised of the following steps:

- Step 1 – Review DQOs and Sampling Design.
- Step 2 – Conduct a Preliminary Data Review.

- Step 3 – Select the Test.
- Step 4 – Verify the Assumptions.
- Step 5 – Draw Conclusions from the Data.

Sample locations that support the presence and/or extent of contamination at CAU 477 are shown in Appendix A. Based on the results of the DQA presented in Appendix C, the DQO requirements have been met, and the close in place with use restrictions corrective action alternative was selected as the closure alternative at CAU 477 (N-Tunnel Muckpile). The DQA also determined that information generated during the investigation supports the CSM assumptions, and the data collected support the intended use in the decision-making process.

2.3 Justification for No Further Action

Use restrictions with no further corrective action is justified based on an evaluation of risk (see Appendix D) to ensure protection of the public and the environment in accordance with NAC 445A (NAC, 2003a), feasibility, and cost effectiveness. The corrective action was determined from DQO decision statements based on a comparison of the analyte concentrations detected in CAI soil samples to the FALs defined in Section 2.3.1. Because the extent of the COCs is limited and the CAI demonstrated that there is no vertical migration through the muckpile into the native material below, the corrective action to close in place with administrative controls is justified at CAU 477. Appendix D presents an evaluation of risk associated with the recommended closure alternative.

2.3.1 Final Action Levels

The CAU 477 FALs are risk-based cleanup goals that, if met, will ensure that each release site will not pose an unacceptable risk to human health or the environment, and that the conditions at each site are in compliance with all applicable laws and regulations. The process described in this section to define and determine the FALs conforms to NAC Section 445A.227 (NAC, 2003a), which lists the requirements for sites with soil contamination. For the evaluation of corrective actions, NAC Section 445A.22705 (NAC, 2003c) requires the use of American Society for Testing and Materials (ASTM) Method E 1739-95 to "conduct an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary remediation standards (i.e., FALs) or to establish that corrective action is not necessary."

The ASTM procedure (ASTM, 1995) defines three tiers (or levels) of evaluation involving increasingly sophisticated analyses as follows.

Tier 1 Evaluation – Sample results from source areas (highest concentrations) are compared to action levels based on generic (non-site-specific) conditions (i.e., the PALs established in the CAIP). The FALs may then be established as the Tier 1 action levels, or the FALs may be calculated using a Tier 2 evaluation.

Tier 2 Evaluation – Conducted by calculating Tier 2 site-specific target levels (SSTLs) using site-specific information as inputs to the same or similar methodology used to calculate Tier 1 action levels. The Tier 2 SSTLs are then compared to individual sample results from reasonable points of exposure (as opposed to the source areas as is done in Tier 1) on a point-by-point basis. Total TPH concentrations are not used for risk-based decisions under Tier 2 or Tier 3. Rather, the individual hazardous constituents in TPH are compared to their SSTLs.

Alternatively, the Tier 2 risk-based corrective action process SSTLs may be compared to the predicted concentration or activity of the contaminant at the point of exposure based on attenuation from the source using relatively simplistic mathematical models. Points of exposure are defined as those locations at which an individual or population may come in contact with a COC originating from a CAS. If a Tier 2 evaluation is conducted, the calculations used to derive the SSTLs and the contaminant attenuation calculations will be provided as an appendix to the investigation report. If remediation to Tier 2 SSTLs is not practical, a Tier 3 evaluation may be conducted.

Tier 3 Evaluation – A Tier 3 evaluation is conducted by calculating SSTLs on the basis of more sophisticated risk analyses using methodologies described in ASTM Method E 1739-95 that consider site-, pathway-, and receptor-specific parameters. Tier 3 evaluation is much more complex than Tiers 1 and 2, because it may include additional site characterization, probabilistic evaluations, and sophisticated chemical fate/transport models. The Tier 3 SSTLs are then compared to the upper 95 percent confidence limit of the mean of sample results from reasonable points of exposure (as opposed to individual sample results as is done in Tier 2). Contaminant concentrations exceeding Tier 3 SSTLs require corrective action. If a Tier 3 evaluation is conducted, the calculations used to derive the SSTLs and the upper confidence limit of the means will be provided as an appendix to the investigation report.

A Tier 1 evaluation was conducted for all COPCs to determine whether contaminant levels satisfy the criteria for regulatory closure or warrant a more site-specific assessment. This was accomplished by comparing individual source area contaminant concentration results to the Tier 1 actions levels (the PALs established in the CAIP).

The constituents detected at CAU 477 that exceeded Tier 1 action levels were:

- TPH-DRO
- Arsenic
- Lead
- Cs-137
- Pb-212

The concentration of all constituents not listed above, were below Tier 1 action levels and the corresponding PALs were established as the Tier 1 FALs. The constituents that exceeded Tier 1 action levels were moved to a Tier 2 evaluation.

The Tier 2 evaluation of TPH-DRO compared the concentrations of the individual hazardous constituents of TPH-DRO to the Tier 1 action levels in the sample that exceeded for TPH-DRO. None of the hazardous constituent concentrations exceeded their Tier 1 action level, so site-specific action levels were not calculated. The PALs were established as the FALs for the hazardous constituents in TPH-DRO at CAU 477. The FALs are presented in Table 2-7. Additional details of the Tier 2 evaluation are provided in Appendix D.

Table 2-7
Tier 2 SSTLs and CAU 480 Results for
Hazardous Constituents of Diesel
(Page 1 of 2)

CAS No.	Common Name	SSTL (mg/kg)	Maximum Reported Value (mg/kg)
108-67-8	1,3,5-Trimethylbenzene	70	0.011
91-57-6	2-Methylnaphthalene[a]	175,000	9.3
120-12-7	Anthracene	100,000	ND
71-43-2	Benzene	2.1	ND
56-55-3	Benzo(a)anthracene	1.4	ND
50-32-8	Benzo(a)pyrene	0.21	ND
205-99-2	Benzo(b)Fluoranthene	2.1	ND
191-24-2	Benzo(g,h,i)Perylene	29,000	ND
207-08-9	Benzo(k)Fluoranthene	21	ND
218-01-9	Chrysene	210	ND
100-41-4	Ethylbenzene	400	ND
206-44-0	Fluoranthene	22,000	ND

Table 2-7
Tier 2 SSTLs and CAU 480 Results for
Hazardous Constituents of Diesel
(Page 2 of 2)

CAS No.	Common Name	SSTL (mg/kg)	Maximum Reported Value (mg/kg)
86-73-7	Fluorene	26,000	ND
91-20-3	Naphthalene	190	ND
104-51-8	N-Butylbenzene	240	0.02
103-65-1	N-Propylbenzene	240	0.015
85-01-8	Phenanthrene	100,000	ND
129-00-0	Pyrene	29,000	ND
108-88-3	Toluene	520	ND
1330-20-7	Total Xylene[b]	420	0.06

[a]Uses PRG for naphthalene as surrogate
[b]Total of m-, o-, and p-xylenes

CAS = Chemical Abstracts Service
mg/kg = Milligrams per kilograms
ND = Nondetect
SSTL = Site-specific target level

None of the chemical constituents exceeded the PALs, so a Tier 2 evaluation was not conducted. The PALs were established as the FALs for the chemical constituents.

The Tier 2 evaluation for the radionuclides was conducted by entering site-specific radionuclide information and physical characteristics of the site into the RESRAD program to calculate the site-specific action levels. This calculated the site-specific activities needed to sum to an exposure dose of 25 millirem per year to a site receptor. These calculated activities were established as the FALs for each radionuclide at the CAS that exceeded a Tier 1 action level. The Tier 2 calculated FALs are presented in Table 2-8. Additional details of the Tier 2 evaluation are provided in Appendix D.

Table 2-8
Final Action Levels

COPCs	Tier 1 FALs	Tier 2 FALs	Tier 3 FALs
VOCs	PALs	N/A	N/A
SVOCs	PALs	N/A	N/A
RCRA metals	PALs except for lead	Lead – 800 mg/kg	N/A
TPH-DRO	PALs	TPH-DRO hazardous constituent PALs	N/A
Radionuclides	PALs except as listed under Tier 2	**CAS 12-06-03** Co-60 3.8E+07 pCi/g, Cs-137 9.0E+11 pCi/g, Pu-238 9.3E+08 pCi/g, Pu-239 5.2E+11 pCi/g	N/A

Co = Cobalt
Cs = Cesium
N/A = Not applicable
pCi/g = Picocuries per gram
Pu = Plutonium

3.0 Recommendations

The data generated by the CAI show that the FAL was exceeded for lead in the muckpile. Although the FAL for lead was exceeded at CAU 477, closure in place with use restrictions is the best option for closing the site. This recommendation is based on the fact that even though the FAL was exceeded in two samples, this remote, controlled access site poses only limited risk overall to public health and the environment. The future use of CAU 477 will be restricted from any activity unless concurrence is obtained from NDEP. The use restriction will prevent inadvertent contact with the COCs, and meets all applicable state and federal regulations for closure of the site.

In conclusion, DTRA requests that NDEP issue a Notice of Completion for this CAU and approval to move the CAU from Appendix III to Appendix IV of the FFACO.

4.0 References

ASTM, see American Society for Testing and Materials.

American Society for Testing and Materials. 1995. *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites/American Society for Testing and Materials*, ASTM E 1739-95 (Reapproved 2002). Philadelphia, PA.

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DOE, see U.S. Department of Energy.

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DTRA, see Defense Threat Reduction Agency.

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FFACO, see *Federal Facility Agreement and Consent Order*.

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Appendix A

Corrective Action Investigation Report for CAU 477, Area 12 N-Tunnel Muckpile, NTS

Table of Contents

List of Tables

A.1.0 Introduction

This report presents a summary of the field activities and the data collected during the CAI of the N-Tunnel Muckpile. The CAI was controlled and guided by the *Corrective Action Investigation Plan for Corrective Action Unit 477: N-Tunnel Muckpile, Nevada Test Site,* Rev. 1 (DTRA, 1999a). The N-Tunnel Muckpile is identified in the FFACO as CAU 477, CAS 12-06-03 (FFACO, 1996).

The N-Tunnel Muckpile is located approximately 45 miles north of Mercury in Area 12 of the Nevada Test Site (see Figure 1-1). N-Tunnel was mined into the bedded ash flow tuff of Rainier Mesa starting in 1961 and continued intermittently until 1993. The muckpile is estimated to contain approximately 8,000,000 cubic feet of mining and reentry debris. Less than one percent of this material is considered to be reentry debris. Additional information relating to the site history, planning, and scope of the investigation is presented in the CAIP (DTRA, 1999a).

A.1.1 Project Objective

The primary objective of the N-Tunnel CAI was to determine whether or not the N-Tunnel Muckpile, the underlying native soils, and/or the underlying retention ponds have been impacted by COPCs at concentrations that exceed regulatory limits. The data collected during the field effort will enable DTRA to make informed decisions about the future operation, use, or closure of the muckpile site. The following tasks were performed to meet the project objective:

- A sonic drill rig was used to drill 33 holes through the muckpile and 5 ft into the native material (only 2 ft, if the native material was bedrock). An additional four holes were drilled to locate and sample the buried retention ponds, and 13 shallow holes (5 ft) were drilled to collect near-surface soil samples.
- Continuous cores were collected from all of the boreholes.
- All of the cores were field screened for VOCs and radioactivity for health and safety purposes and to identify the location of optional environmental samples.
- Soil samples were collected from random depths within the muckpile, from 5 ft (or 2 ft, if bedrock) below the muckpile/native material interface, and from the surface/near-surface (less than 5 ft below ground surface [bgs]) of the muckpile.
- Soil samples were collected from the retention ponds that were covered by the muckpile.

- Samples were sent to an off-site laboratory for analysis for VOCs, SVOCs, total RCRA metals, and radionuclides.
- Three background samples of native soil were collected using hand tools and analyzed for total RCRA metals and gamma spectroscopy at the off-site laboratory.
- All of the cores were described to assess soil and waste physical characteristics.

A.1.2 Report Content

The CAI report is intended to provide information and data in sufficient detail to support the selection of a preferred corrective action alternative reported in the CADD. The contents of this CAI report are as follows:

- Section A.1.0 of this report is the introduction which includes a description of the objective and scope of the project.
- Section A.2.0 details the muckpile investigation and provides a description of the sample collection activities and locations.
- Section A.3.0 is a summary of the sample analytical results.
- Section A.4.0 discusses the quality assurance (QA) and quality control (QC) procedures that were followed and the results of the QA and QC activities.
- Section A.5.0 summarizes the significant results of the CAI.
- Section A.6.0 lists the references cited.

To provide a concise summary, the complete field documentation and laboratory data is not contained in this report. These documents are retained in project files.

A.2.0 Field Investigation and Sampling Activities

The field investigation and sampling program were managed in accordance with the requirements set forth in the CAIP (DTRA, 1999a). The field activities were performed in accordance with an approved site-specific health and safety plan (SSHASP) (IT, 1999). The samples were collected and documented by following approved sampling, field activity and sample collection documentation, decontamination, chain-of-custody, shipping, and radiation screening protocols and procedures. Quality control samples (e.g., equipment rinsate blanks, trip blanks, and sample duplicates) were collected as required by the CAIP and in accordance with approved procedures.

A.2.1 Slope Stability Analysis

Prior to the commencement of the sonic drilling, field and laboratory tests were conducted to characterize the existing material conditions at the site so that safe working distances from the edge of the muckpile could be calculated. Using the results of field and laboratory testing, a slope stability analysis was performed by Bechtel Nevada (BN) to identify possible slope stability hazards on both the upper and lower muckpile benches.

Given the site conditions and proposed operating parameters the slope stability analysis indicated that drilling could be safely conducted as long as the holes were more than 50 ft from the edge of the lower bench and 25 ft from the edge of the upper bench.

A.2.2 Borehole Locations

Prior to the commencement of the drilling operations, BN surveyors located the boreholes on the muckpile at coordinates calculated using the random numbers. A detailed explanation of the methodology for selection of the random numbers is presented in the *N-Tunnel Muckpile Sampling and Analysis Plan* (DNA, 1992). Though only 30 holes were necessary to collect the required number of soil samples, the location for 50 boreholes were staked. The three background sample locations were also surveyed. Once these 50 holes were staked, DTRA and IT Corporation personnel visited the site to determine which of the locations were accessible to the drill rig. In addition, 13 shallow borehole locations were selected and staked based on knowledge of past site operations to represent biased locations most likely to be contaminated.

The location of one buried pond was staked based on coordinates taken from an as-built drawing dated March 11, 1969. Upon completion of the drilling, the exact locations of the shallow soil borings and the pond boreholes were surveyed. A list of the borehole locations is provided in Table A.2-1.

Table A.2-1
Borehole Locations, Total Depth, and Sampling Depths
(Page 1 of 3)

Hole #	Northing	Easting	Collar Elevation (ft)	Sample Depth(s) (ft)	Bottom of Muckpile (ft)	Total Depth (ft)/Comments
1	892518	638418	6,025.2	3.5, 7	5	7
2	891975	638704	5,994.6	19**, 26, 57	55	57
3*	892210	638898	6,002.5	ns	N/A	On slope, cannot set up rig
4	892336	638277	6,021.2	13, 20	16	20
5	892066	638541	5,996.3	10, 33	31	39
6*	892201	639084	6,018.9	ns	N/A	Too close to the edge
7	891944	638988	5,991.3	61, 82	77	87
8	891972	638746	5,994.3	47, 63	58	66
9*	892181	639081	6,007.5	ns	N/A	Too close to the edge
10	891944	639196	5,987.5	88, 100	100	101
11*	892208	639210	6,016.5	ns	N/A	On berm edge, cannot set up rig
12	891990	639160	5,989.1	66, 78, 87.5	86	87.5
13	891918	639048	5,989.6	21, 89	84	90
14*	892309	639457	nsu	ns	N/A	Not on muckpile
15	891940	638651	5,994.9	16, 24	22	26
16	892179	638620	6,021.1	10, 72	69.5	72
17	892072	639252	5,988.3	36, 40	37	40
18	891885	638680	5,994.6	10, 21	19.5	22
19	892414	638689	6,022.5	2, 17	14.8	17
20	892082	639348	5,986.3	9, 31	26	40
21	892501	638499	6,024.0	5.5, 19	17	19
22*	892114	638501	6,016.1	ns	N/A	On ramp, cannot set up rig
23	892497	638395	6,024.6	2, 5	4	5.5
24	892079	639381	5,985.8	20, 35	30	36
25	892546	638486	6,024.7	4, 9.5	4.5	9.5
26	892131	639118	5,991.2	64, 79	34.5	80

Table A.2-1
Borehole Locations, Total Depth, and Sampling Depths
(Page 2 of 3)

Hole #	Northing	Easting	Collar Elevation (ft)	Sample Depth(s) (ft)	Bottom of Muckpile (ft)	Total Depth (ft)/Comments
27	892037	638596	5,995.3	ns	N/A	Refusal at 6 ft, not sampled
28*	892202	638414	6,022.8	ns	N/A	Located inside building 12-906
29	892055	639005	5,991.6	83, 85	80.5	85
30*	892428	638674	6,022.6	ns	N/A	Too close to building 12-855
31	892143	638344	5,999.0	37, 43	39	43
32*	0	0	nsu	ns	N/A	Not listed in the original CAIP
33*	892363	639040	nsu	ns	N/A	Not on muckpile
34*	892282	638699	6,020.9	ns	N/A	Hole located under a large tank
35	892504	638617	6,022.3	19, 51	49	51
36	892533	638449	6,024.6	6	4	7
37	892524	638671	6,022.9	12, 29	26	29
38*	892216	639205	nsu	ns	N/A	Not on muckpile
39	892109	639242	5,988.7	14, 28	26	28
40	892185	638340	6,000.7	7**, 19, 50	47.5	50
41	892149	638932	5,993.2	18, 49	44	50
42*	892158	639464	nsu	ns	N/A	Not surveyed
43	892287	638968	6,021.9	47, 60	59	62
44*	892282	639080	nsu	ns	N/A	Too close to the edge
45*	892286	639275	nsu	ns	N/A	Too close to the edge
46	892228	638539	6,022.1	13.5**, 75, 85	85	86.5
47	892139	639193	5,990.1	13, 22.5	17.5	23
48	892149	638929	5,993.3	27, 47	42	49
49*	892163	638485	6,018.7	ns	N/A	On road, cannot set up drill rig
50	892664	638566	6,023.7	10, 18.5	13.5	20
BG1	891800	638200	6,040.7	0.5	N/A	0.5
BG2	891640	639000	5,911.0	ns	N/A	On the road bed, not sampled
BG2A	891501	638968	5,940.3	0.5	N/A	0.5
BG3	892480	639080	6,132.1	0.5	N/A	0.5

Table A.2-1
Borehole Locations, Total Depth, and Sampling Depths
(Page 3 of 3)

Hole #	Northing	Easting	Collar Elevation (ft)	Sample Depth(s) (ft)	Bottom of Muckpile (ft)	Total Depth (ft)/Comments
S1	892287	638863	6,020.7	1	N/A	5
S2	892240	639000	6,019.4	1	N/A	5
S3	892218	639112	6,017.9	1	N/A	5
S4	892203	639209	6,016.9	1	N/A	5
S5	892217	639341	6,015.1	1	N/A	5
S6	892691	638575	6,023.7	1	N/A	5
S7	892521	638636	6,022.5	1	N/A	5
S8	892572	638444	6,025.5	2	N/A	5
S9	892253	638460	6,023.4	2	N/A	5
S10	892176	638531	6,021.7	1	N/A	5
S11	892179	638790	5,995.5	2.5	N/A	5
S12	892140	639319	5,985.7	2.5	N/A	5
S13	892223	639749	5,976.5	2	N/A	5
A	892238	638621	6,021.1	81	81	83
B	892215	638641	6,020.7	85, 95	85	96
C	891980	639126	5,989.5	94, 99	94	99
F	892006	639061	5,990.2	95	95.5	97.5

* Indicates the hole was not drilled
** Biased sample

ft = Foot
N/A = Not applicable
ns = Not sampled
nsu = Not surveyed

A.2.3 Subsurface Characterization

Thirty-three vertical boreholes were drilled into the muckpile for subsurface characterization. The rotary sonic (rotosonic) drilling method was used to produce continuous soil cores for detailed lithologic descriptions and sampling of the subsurface soil. Thirty-two samples were collected at the predetermined depth calculated from the total depth of the borehole and 33 samples were collected from 5 ft below the native soil/muckpile interface. All borings were drilled to a depth of 5 ft below the native soil/muckpile interface with the exception of holes where bedrock was encountered. Holes where bedrock was encountered were drilled 2 ft into the bedrock and sampled.

The entire core was field screened for radioactivity and VOCs. Field screening was used to indicate locations for additional biased sampling for characterization. Three additional samples were taken based on decision criteria for additional sampling contained in the CAIP (DTRA, 1999a). All of the soil samples were sent to an off-site laboratory to be analyzed for VOCs, SVOCs, TPH-gasoline, TPH-diesel, total RCRA metals, and radionuclides.

The only drilling problem encountered was refusal in borehole number 27 at a depth of 6 ft. The decision was made to abandon the hole and pick an alternate location.

A.2.4 Muckpile Surface Samples (0 to 5 ft)

Shallow soil sampling consisted of drilling 13 5-ft deep boreholes into the muckpile using the rotosonic drill rig and extracting a core. These cores were logged and screened prior to collecting a soil sample at either 1 to 2 ft or the depth at which field screening indicated elevated VOC or radionuclide levels. One soil sample was collected from each of the 13 boreholes. These soil samples were sent to an off-site laboratory to be analyzed for VOCs, SVOCs, TPH-gasoline, TPH-diesel, total RCRA metals, and radionuclides.

A.2.5 Background Native Soil Samples (0.5 ft)

Background soil samples were collected at three locations near the N-Tunnel Muckpile to use as a baseline for comparison with the muckpile samples. The samples were collected from a depth of 6 inches using decontaminated hand tools and disposable Teflon® scoops. The samples were sent to the off-site laboratory to be analyzed for total RCRA metals and radionuclides.

A.2.6 Buried Retention Pond Samples

The pond soil sampling consisted of drilling boreholes through the muckpile and into the native material underneath. This was an attempt to intersect two retention ponds that had been covered by the muckpile. A total of 375.5 ft was drilled in four boreholes (A, B, C, and F) to attempt to intersect the ponds. In addition, Borehole 12 was located such that it intersected a third pond. The boreholes varied in depth from 83 to 99 ft. Of the five boreholes drilled at suspected pond locations, pond material was only identified in three of them (Boreholes A, B, and 12). Samples were collected from each of these boreholes. In addition, samples of the native material were collected at the bottom of each hole. For the holes that did not intersect pond material, a sample was collected at the bottom of the hole. A sample was also collected at the muckpile/native interface of Borehole C.

All of the soil samples were sent to an off-site laboratory to be analyzed for VOCs, SVOCs, TPH-gasoline, TPH-diesel, total RCRA metals, and radionuclides.

A.2.7 Other Sampling

In addition to the environmental samples, four blind duplicate samples were collected and analyzed to assure laboratory consistency; four matrix spike/matrix spike duplicate (MS/MSD) samples were collected to check for matrix interference; seven rinsate samples were collected to check on the effectiveness of the decontamination procedures; and 32 trip blanks were sent with the VOC samples.

A.3.0 Results

The analytical results of samples collected from the N-Tunnel Muckpile CAI have been compiled and evaluated to determine the presence and extent of the contamination. The results are summarized in the following subsections. Complete laboratory results are available in the project files.

A total of 96 soil samples (characterization) and 39 water samples (QC trip blanks and rinsate blanks) were collected and submitted for analysis. Three of the soil samples were submitted to establish background levels. A list of sample numbers and their relationship to the boreholes is presented in Table A.3-1. The analytical parameters and methods requested for the CAI samples submitted to the off-site laboratory are presented in Table A.3-2. All samples were submitted to Paragon Analytics of Fort Collins, Colorado. Third-party data validation was completed by The IT Group in Cincinnati, Ohio. The samples that had laboratory-reported detections (above the method detection limit) are listed in Tables A.3-3 or A.3.4.

A.3.1 Total Volatile Organic Compounds and Total Semivolatile Organic Compounds

Volatile organics compounds and SVOCs were detected in samples throughout the muckpile, in the native soils, and in the background samples at levels above the method detection limit. No VOCs or SVOCs were detected above the action levels presented in the CAIP (DTRA, 1999a). Most of the constituents detected are common laboratory artifacts.

A.3.2 Total Petroleum Hydrocarbons

There were no detections of TPH-gasoline that exceeded the action levels in any of the CAI samples. Of the TPH-diesel detections, there were nine that exceeded the action levels. Concentrations detected in the samples ranged from 120 mg/kg to 3,300 mg/kg. The majority of the locations were shallow subsurface muckpile samples.

Table A.3-1
Samples Collected and Submitted for Laboratory Analyses
for the CAU 477 N-Tunnel Muckpile Corrective Action Investigation
(Page 1 of 4)

Borehole Number	Sample Number	Depth (ft bgs)	Sample Matrix	Soil Type	Comments	Parameters Analyzed
1	NS-01-03.5	3.5	Soil	Muckpile	-	Full Suite
	NS-01-07	7	Soil	Native	-	Full Suite
2	NS-02-19	19	Soil	Muckpile	-	Full Suite
	NS-02-26	26	Soil	Muckpile	MS/MSD	Full Suite
	NS-02-57	57	Soil	Native	-	Full Suite
4	NS-04-13	13	Soil	Muckpile	-	Full Suite
	NS-04-20	20	Soil	Native	-	Full Suite
5	NS-05-10	10	Soil	Muckpile	-	Full Suite
	NS-05-33	33	Soil	Native	-	Full Suite
7	NS-07-61	61	Soil	Muckpile	-	Full Suite
	QNS-07-61	61	Soil	Muckpile	Field Dup NS-07-61	Full Suite
	NS-07-82	82	Soil	Native	-	Full Suite
8	NS-08-47	47	Soil	Muckpile	-	Full Suite
	NS-08-63	63	Soil	Native	-	Full Suite
10	NS-10-100	100	Soil	Muckpile	MS/MSD	Full Suite
	NS-10-88	88	Soil	Native	-	Full Suite
12	NS-12-66	66	Soil	Muckpile	-	Full Suite
	NS-12-78	78	Soil	Pond	-	Full Suite
	NS-12-87.5	87.5	Soil	Native	-	Full Suite
13	NS-13-21	21	Soil	Muckpile	-	Full Suite
	NS-13-89	89	Soil	Native	-	Full Suite
15	NS-15-16	16	Soil	Muckpile	-	Full Suite
	NS-15-24	24	Soil	Native	-	Full Suite
16	NS-16-10	10	Soil	Muckpile	-	Full Suite
	QNS-16-10	10	Soil	Muckpile	Field Dup NS-16-10	Full Suite
	NS-16-72	72	Soil	Native	-	Full Suite
17	NS-17-36	36	Soil	Muckpile	-	Full Suite
	NS-17-40	40	Soil	Native	-	Full Suite
18	NS-18-10	10	Soil	Muckpile	-	Full Suite
	NS-18-21	21	Soil	Native	-	Full Suite
19	NS-19-02	2	Soil	Muckpile	-	Full Suite
	NS-19-17	17	Soil	Native	-	Full Suite
20	NS-20-09	9	Soil	Muckpile	-	Full Suite
	QNS-20-09	09	Soil	Muckpile	Field Dup NS-20-09	Full Suite
	NS-20-31	31	Soil	Native	-	Full Suite

Table A.3-1
Samples Collected and Submitted for Laboratory Analyses
for the CAU 477 N-Tunnel Muckpile Corrective Action Investigation
(Page 2 of 4)

Borehole Number	Sample Number	Depth (ft bgs)	Sample Matrix	Soil Type	Comments	Parameters Analyzed
21	NS-21-5.5	5.5	Soil	Muckpile	-	Full Suite
	QNS-21-5.5	5.5	Soil	Muckpile	Field Dup NS-21-5.5	Full Suite
	NS-21-19	19	Soil	Native	-	Full Suite
23	NS-23-02	2	Soil	Muckpile	-	Full Suite
	NS-23-05	6	Soil	Native	-	Full Suite
24	NS-24-20	20	Soil	Muckpile	-	Full Suite
	NS-24-35	35	Soil	Native	-	Full Suite
25	NS-25-04	4	Soil	Muckpile	-	Full Suite
	NS-25-9.5	9.5	Soil	Native	-	Full Suite
26	NS-26-64	64	Soil	Muckpile	-	Full Suite
	NS-26-79	79	Soil	Native	-	Full Suite
29	NS-29-83	83	Soil	Muckpile	-	Full Suite, Alpha
	NS-29-85	85	Soil	Native	-	Full Suite, Alpha
31	NS-31-37	37	Soil	Muckpile	MS/MSD	Full Suite
	NS-31-43	43	Soil	Native	-	Full Suite
35	NS-35-19	19	Soil	Muckpile	-	Full Suite
	NS-35-51	51	Soil	Native	-	Full Suite
36	NS-36-06	6	Soil	Native	-	Full Suite
37	NS-37-12	12	Soil	Muckpile	-	Full Suite
	NS-37-29	29	Soil	Native	-	Full Suite
39	NS-39-14	14	Soil	Muckpile	-	Full Suite
	NS-39-28	28	Soil	Native	-	Full Suite
40	NS-40-7	19	Soil	Muckpile	-	Full Suite
	NS-40-19	50	Soil	Muckpile	-	Full Suite
	NS-40-50	7	Soil	Native	-	Full Suite
41	NS-41-18	18	Soil	Muckpile	-	Full Suite, Alpha
	NS-41-49	49	Soil	Native	-	Full Suite, Alpha
43	NS-43-47	47	Soil	Muckpile	-	Full Suite
	NS-43-60	60	Soil	Native	-	Full Suite
46	NS-46-13.5	13.5	Soil	Muckpile	-	Full Suite
	NS-46-75	75	Soil	Muckpile	MS/MSD	Full Suite
	NS-46-85	85	Soil	Native	-	Full Suite
47	NS-47-13	13	Soil	Muckpile	-	Full Suite
	NS-47-22.5	22.5	Soil	Native	-	Full Suite
48	NS-48-27	27	Soil	Muckpile	-	Full Suite
	NS-48-47	47	Soil	Native	-	Full Suite

Table A.3-1
Samples Collected and Submitted for Laboratory Analyses
for the CAU 477 N-Tunnel Muckpile Corrective Action Investigation
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Borehole Number	Sample Number	Depth (ft bgs)	Sample Matrix	Soil Type	Comments	Parameters Analyzed
50	NS-50-10	10	Soil	Muckpile	-	Full Suite
	NS-50-18.5	18.5	Soil	Native	-	Full Suite
A	NS-A-81	81	Soil	Pond	Ponds	Full Suite
B	NS-B-85	85	Soil	Pond	Ponds	Full Suite
	NS-B-95	95	Soil	Native	Ponds	Full Suite
B1	NS-B1-0.5	0.5	Soil	Native	Background Sample	RCRA Metals, Gamma Spec
B2	NS-B2-0.5	0.5	Soil	Native	Background Sample	RCRA Metals, Gamma Spec
B3	NS-B3-0.5	0.5	Soil	Native	Background Sample	RCRA Metals, Gamma Spec
C	NS-C-94	94	Soil	Native	Ponds	Full Suite
	NS-C-99	99	Soil	Native	Ponds	Full Suite
F	NS-F-95	95	Soil	Native	Ponds	Full Suite
S1	NS-S1-01	1	Soil	Muckpile	Shallow Boring	Full Suite
S10	NS-S10-01	1	Soil	Muckpile	Shallow Boring	Full Suite
S11	NS-S11-02.5	2.5	Soil	Muckpile	Shallow Boring	Full Suite
S12	NS-S12-2.5	2.5	Soil	Muckpile	Shallow Boring	Full Suite
S13	NS-S13-01	1	Soil	Muckpile	Shallow Boring	Full Suite
S2	NS-S2-01	1	Soil	Muckpile	Shallow Boring	Full Suite
S3	NS-S3-01	1	Soil	Muckpile	Shallow Boring	Full Suite
S4	NS-S4-01	1	Soil	Muckpile	Shallow Boring	Full Suite
S5	NS-S5-01	1	Soil	Muckpile	Shallow Boring	Full Suite
S6	NS-S6-01	1	Soil	Muckpile	Shallow Boring	Full Suite
S7	NS-S7-01	1	Soil	Muckpile	Shallow Boring	Full Suite
S8	NS-S8-02	2	Soil	Muckpile	Shallow Boring	Full Suite
S9	NS-S9-02	2	Soil	Muckpile	Shallow Boring	Full Suite
N/A	NW-10	N/A	Water	N/A	Rinsate Blank	Full Suite
N/A	NW-15	N/A	Water	N/A	Rinsate Blank	Full Suite
N/A	NW-16-01	N/A	Water	N/A	Rinsate Blank	Full Suite
N/A	NW-29	N/A	Water	N/A	Rinsate Blank	Full Suite, Alpha
N/A	NW-50	N/A	Water	N/A	Rinsate Blank	Full Suite
N/A	NW-S7-1	N/A	Water	N/A	Rinsate Blank	Full Suite
N/A	NW-S7-2	N/A	Water	N/A	Rinsate Blank	Full Suite
N/A	TR1-0317	N/A	Water	N/A	Trip Blank	VOC
N/A	TR10-0324	N/A	Water	N/A	Trip Blank	VOC
N/A	TR11-0324	N/A	Water	N/A	Trip Blank	VOC

Table A.3-1
Samples Collected and Submitted for Laboratory Analyses
for the CAU 477 N-Tunnel Muckpile Corrective Action Investigation
(Page 4 of 4)

Borehole Number	Sample Number	Depth (ft bgs)	Sample Matrix	Soil Type	Comments	Parameters Analyzed
N/A	TR12-0330	N/A	Water	N/A	Trip Blank	VOC
N/A	TR13-0401	N/A	Water	N/A	Trip Blank	VOC
N/A	TR14-0402	N/A	Water	N/A	Trip Blank	VOC
N/A	TR15-0407	N/A	Water	N/A	Trip Blank	VOC
N/A	TR16-0408	N/A	Water	N/A	Trip Blank	VOC
N/A	TR17-0408	N/A	Water	N/A	Trip Blank	VOC
N/A	TR18-0411	N/A	Water	N/A	Trip Blank	VOC
N/A	TR19-0412	N/A	Water	N/A	Trip Blank	VOC
N/A	TR2-0318	N/A	Water	N/A	Trip Blank	VOC
N/A	TR20-0413	N/A	Water	N/A	Trip Blank	VOC
N/A	TR21-0415	N/A	Water	N/A	Trip Blank	VOC
N/A	TR22-0420	N/A	Water	N/A	Trip Blank	VOC
N/A	TR23-0420	N/A	Water	N/A	Trip Blank	VOC
N/A	TR24-0421	N/A	Water	N/A	Trip Blank	VOC
N/A	TR25-0422	N/A	Water	N/A	Trip Blank	VOC
N/A	TR26-0423	N/A	Water	N/A	Trip Blank	VOC
N/A	TR27-0423	N/A	Water	N/A	Trip Blank	VOC
N/A	TR28-0424	N/A	Water	N/A	Trip Blank	VOC
N/A	TR29-0425	N/A	Water	N/A	Trip Blank	VOC
N/A	TR3-0318	N/A	Water	N/A	Trip Blank	VOC
N/A	TR30-0425	N/A	Water	N/A	Trip Blank	VOC
N/A	TR31-0426	N/A	Water	N/A	Trip Blank	VOC
N/A	TR32-0427	N/A	Water	N/A	Trip Blank	VOC
N/A	TR4-0318	N/A	Water	N/A	Trip Blank	VOC
N/A	TR5-0319	N/A	Water	N/A	Trip Blank	VOC
N/A	TR6-0320	N/A	Water	N/A	Trip Blank	VOC
N/A	TR7-0321	N/A	Water	N/A	Trip Blank	VOC
N/A	TR8-0322	N/A	Water	N/A	Trip Blank	VOC
N/A	TR9-0324	N/A	Water	N/A	Trip Blank	VOC

Full Suite = VOC, SVOC, TPH-gasoline, TPH-diesel/oil, RCRA Metals, Gamma Spec
N/A = Not applicable

Table A.3-2
Chemical Analytical Methods Used for N-Tunnel Investigation Samples

Analyte	Medium[a]	Analytical Method
Total VOCs	Water	8260B[b]
	Soil	
Total SVOCs	Water	8270C[b]
	Soil	
Total RCRA Metals Arsenic Barium Cadmium Chromium Lead Selenium Silver Mercury	Water	6010B/7470A[b]
Arsenic Barium Cadmium Chromium Lead Selenium Silver Mercury	Soil	6010B/7471A[b]
Total Petroleum Hydrocarbons	Water (gasoline)	8015B modified[b]
	Water (diesel/oil)	
	Soil (gasoline)	
	Soil (diesel/oil)	
Gamma Spectroscopy	Water	L-E10.602.PC[c,d]
	Soil	

[a]Includes methods for QC (water) samples.
[b]Environmental Protection Agency, Test Methods for Evaluating Solid Waste, 3rd Edition, Parts 1-4, SW-846 (EPA, 1996).
[c]Bechtel Nevada Analytical Services Laboratory Procedures Manual (BN, 1996) or equivalent.
[d]Isotopic minimum detectable concentrations are defined during the Data Quality Objective process and are specified in the Corrective Action Decision Document, if applicable.

RCRA = *Resource Conservation and Recovery Ac*t
SVOC = Semivolatile organic compound
VOC = Volatile organic compound

A.3.3 Total RCRA Metals Results

If the total metals result for a specific metal divided by 20 exceeded the maximum concentration of contamination (MCC) for the toxicity characteristic (40 *Code of Federal Regulations* 261.24 [CFR, 1999]), the sample was reanalyzed using toxicity characteristic leaching procedure (TCLP) to determine if the contaminant level of the leachate would exceed the MCC. Ten samples were reanalyzed using the TCLP, and the results are reported in Table A.3.3 if the MCC was exceeded.

Lead was detected in two boreholes at levels that exceed the action levels. In sample NS-23-02, lead was detected at a concentration of 59,700 mg/kg; and, in sample NS-46-13.5, lead was detected at a concentration of 2,040 mg/kg. Additional TCLP results were nondetectable for lead in sample NS-23-02 and 2.7 mg/L for sample NS-46-13.5.

Arsenic was also detected at levels exceeding the industrial PRG (3.0 mg/kg) in 70 of the 96 soil samples collected, including all three of the background samples. Based on background levels published by the Nevada Bureau of Mines and Geology (1998), arsenic levels encountered during this investigation can be considered representative of ambient conditions with the exception of one sample (NS-23-02), where the concentration was reported to be 38.8 mg/kg of arsenic.

A.3.4 Gamma Spectroscopy Results

Four radiological isotopes were discovered at two sample locations (NS-46-13.5 and NS-17-36) that exceeded background activities: cobalt-60, cesium-137, plutonium-238, and plutonium-239. Other detected analytes were representative of naturally occurring isotopes in concentrations that were not statistically significant when compared to background.

For a discussion of the results and an analysis of whether they met the DQOs, see Appendices C and D of this document.

Table A.3-3
VOCs, SVOCs, Total Metals, and TCLP Metals Detects for the N-Tunnel Muckpile Investigation

(Page 1 of 3)

Compounds	Units	Background Range	# of Detects	Surface Soil Range	# of Detects	Subsurface Muckpile Range	# of Detects	Native Range	# of Detects	Pond Range	# of Detects	QA/QC Range	# of Detects
Volatile Organic Compounds													
1,2-dibromo-3-chloropropane	µg/kg							2.1	1				
1,2-dichlorobenzene	µg/kg							1	1				
1,2,4-trimethylbenzene	µg/kg					180	1						
1,3,5-trimethylbenzene	µg/kg					59	1						
1-chlorohexane	µg/kg			1.5	1	1.1 - 2.6	2						
2-butanone	µg/kg			4.2 - 5	3	2.2 - 11	10	2 - 5.9	6				
Acetone	µg/kg			13 - 53	3	9.3 - 180	19	9.2 - 32	13	12 - 29	5		
Acetone	µg/L											10 - 31	9
Carbon tetrachloride	µg/kg					2	1						
Chlorobenzene	µg/kg							0.69	1				
Chloroform	µg/kg					1.8	1						
Chloroform	µg/L											1.5 - 2.5	7
Chloromethane	µg/kg					5.1	1						
Chloromethane	µg/L											2.9	1
Ethylbenzene	µg/kg					0.82 - 6.4	5	0.82	1	1	1		
Isopropylbenzene	µg/kg					7.2	1						
m+p-xylene	µg/kg					1.8 - 35	6	1.9	1	3	1		
Methylene chloride	µg/L											1.5	1
n-butylbenzene	µg/kg					20	1						
n-propylbenzene	µg/kg					15	1						
Naphthalene	µg/kg					3.1 - 7000	3	1.2 - 2.6	2				
Naphthalene	µg/L											1.3	1
O-xylene	µg/kg					0.94 - 25	3						

Table A.3-3
VOCs, SVOCs, Total Metals, and TCLP Metals Detects for the N-Tunnel Muckpile Investigation

(Page 2 of 3)

Compounds	Units	Background Range	# of Detects	Surface Soil Range	# of Detects	Subsurface Muckpile Range	# of Detects	Native Range	# of Detects	Pond Range	# of Detects	QA/QC Range	# of Detects
P-isopropyltoluene	µg/kg					18 - 79	2	0.67 - 0.92	2				
Sec-butylbenzene	µg/kg					15	1						
Styrene	µg/kg									1.1	1		
Tert-butylbenzene	µg/kg							0.83	1				
Toluene	µg/kg					1.2 - 1.7	2	0.78	1				
Trichloroethene	µg/kg					1.2	1	0.83	1				
Semivolatile Organic Compounds													
2-methylnaphthalene	µg/kg					13,000	1						
4-chloro-3-methylphenol	µg/kg			170 - 180	2	180 - 4800	4	170 - 180	4				
Benzo(g,h,I)perylene	µg/kg							120 - 140	3				
Bis(2-ethylhexyl)phthalate	µg/kg			250	1	69 - 850	3	200 - 220	2				
Bis(2-ethylhexyl)phthalate	µg/L											1.6 - 18	2
Dimethyl phthalate	µg/kg			96 - 98	2	96 - 2500	4	94 - 100	3				
Pyrene	µg/kg					4300	1						
Petroleum Hydrocarbons													
Gasoline	mg/kg					0.68	1						
Gasoline	mg/L											0.03	2
Diesel-range organics	mg/kg			4.6 - 760	13	3.1 - 3300	36	2.6 - 22	23	3.7 - 48	5		
Diesel-range organics	mg/L											0.89	1
Metals (Total and TCLP)													
Arsenic	mg/kg	3.4 - 6.5	3	2.4 - 9.6	13	2.2 - 38.8	38	1.3 - 6.6	35	2.3 - 5	6		
Barium (total)	mg/kg	83.7 - 156	3	225 - 5300	13	38.3 - 5100	37	22.9 - 1290	35	52.2 - 4610	6		

Table A.3-3
VOCs, SVOCs, Total Metals, and TCLP Metals Detects for the N-Tunnel Muckpile Investigation

(Page 3 of 3)

Compounds	Units	Background Range	# of Detects	Surface Soil Range	# of Detects	Subsurface Muckpile Range	# of Detects	Native Range	# of Detects	Pond Range	# of Detects	QA/QC Range	# of Detects
Barium (TCLP)	µg/L			384 - 519	3	251 - 920	6						
Barium (water)	µg/L											0.77 - 18.1	5
Cadmium	mg/kg			0.07	1	0.11 - 0.46	4						
Chromium (total)	mg/kg	1.7 - 5.5	3	1.5 - 13.3	13	0.68 - 11.7	35	0.29 - 8.6	31	1.4 - 3.6	6		
Chromium (TCLP)	µg/L											0.45 - 0.79	2
Lead (total)	mg/kg	14 - 23	3	7.3 - 75.9	13	5.7 - 59,700	38	2.3 - 44.1	35	9.1 - 20.8	6		
Lead (TCLP)	µg/L					2720	1						
Mercury	mg/kg			0.04 - 0.07	3	0.06 - 0.29	19	0.04 - 0.8	26	0.04 - 0.16	4		
Selenium	mg/kg			0.45 - 1.1	3								
Silver	mg/kg			0.63	1	0.18 - 1.1	5	0.49 - 1.3	5				

µg/kg =Micrograms per kilogram
µg/L = Micrograms per liter
mg/L = Milligrams per liter

Table A.3-4
Radionuclide Detects for the N-Tunnel Muckpile Investigation

Radionuclide	Units	Background Range	# of Detects	Surface Soil Range	# of Detects	Subsurface Soil Range	# of Detects	Native Range	# of Detects	Pond Range	# of Detects	QA/QC Range	# of Detects
Actinium-228	pCi/g	1.82 - 3.4	3	0.93 - 2.16	11	1.23 - 2.62	33	1.41 - 3.18	33	1.72 - 2.42	6	1.41 - 2.43	4
Bismuth-212	pCi/g	1.7 - 2.7	2	2.9 - 3.8	3	1.5 - 3.7	6	2.8 - 4.3	9	3 - 3.6	3		
Bismuth-214	pCi/g	0.92 - 1.58	3	0.82 - 1.47	12	0.58 - 2.34	37	0.6 - 4.88	33	0.71 - 1.56	6	0.72 - 2.34	4
Cobalt-60	pCi/g					0.73	1						
Cesium-137	pCi/g	1.07	1	0.86	1	0.4 - 1340	7	0.37 - 1.54	2	0.26 - 0.32	2	0.43	1
Potassium-40	pCi/g	22.4 - 31.8	3	17.7 - 33.4	13	15.1 - 41.1	38	19.5 - 42.5	35	28.8 - 40.5	6	25.8 - 33	4
Lead-212	pCi/g	1.83 - 3.33	3	1.28 - 2.25	13	0.68 - 2.63	38	0.256 - 3.1	34	1.67 - 2.34	6	2.09 - 2.63	4
Lead-214	pCi/g	0.97 - 1.67	3	0.87 - 1.42	12	0.73 - 2.51	37	0.66 - 5.08	33	0.84 - 1.68	6	0.76 - 2.51	4
Plutonium-238	pCi/g					0.048 - 0.272	2						
Plutonium-239	pCi/g					0.454 - 0.55	2						
Thallium-208	pCi/g	0.76 - 1.19	3	0.47 - 0.78	9	0.43 - 0.86	28	0.58 - 1.04	29	0.59 - 0.8	5	0.74 - 0.86	3

pCi/g =Picocuries per gram

A.4.0 Quality Assurance

The following text outlines the results of the QA/QC activities. Detailed information on the QA program for this CAI is contained in the Industrial Sites Quality Assurance Project Plan (QAPP) (DOE/NV, 1996). A detailed data assessment is presented in Appendix C of this document.

Quality control results are typically discussed in terms of the five PARCC parameters (precision, accuracy, representativeness, completeness, and comparability) as described in the following sections.

A.4.1 Precision

Precision is a quantitative measure of the variability of a group of measurements from their average value. Precision is assessed by collecting and analyzing duplicate field samples and comparing the results with the original sample. Precision is also assessed by creating, analyzing, and comparing laboratory duplicates from one or more field samples. Precision is reported as relative percent difference (RPD) which is calculated as the difference between the measured concentrations of duplicate samples, divided by the average of the two concentrations, and multiplied by 100. Any deviations from these requirements have been documented and explained and the related data qualified accordingly. The qualification process is described in Section A.4.6.

A.4.2 Accuracy

Field accuracy is defined as the nearness of a measurement to the true or accepted reference value. It is the composite of the random and systematic components of the measurement system and measures bias in a measurement system. The random component of accuracy is measured and documented through the analyses of spiked samples. Sampling accuracy is assessed by evaluating the results of spiked samples and laboratory control samples. Accuracy measurements are calculated as percent recovery (%R) by dividing the measured sample concentration by the true concentration and multiplying the quotient by 100.

Field accuracy is assessed by confirming that the documents of record track the sample from origin, through transfer of custody, to disposal. The goal of field accuracy is for all samples to be collected from the correct locations at the correct time, placed in a correctly labeled container

with the correct preservative, and sealed with custody tape to prevent tampering. All samples in this sampling event were properly collected and forwarded to the laboratory as described above.

A.4.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition (EPA, 1987). Sample representativeness was achieved through the implementation of a sampling program designed to ensure proper sampling locations, number of samples, and the use of validated analytical methods. Representativeness was assessed through analysis of duplicate samples. Representativeness of the samples taken in this sampling event was assured by collecting the required samples shown in Table A.3-1 and by analyzing them using the approved analytical methods shown in Table A.3-2.

A.4.4 Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid. A sampling and analytical requirement with 90 percent confidence level was established for this project (DTRA, 1999a). The sampling and analytical programs were executed in accordances with approved field sampling instructions (DTRA, 1999b). The specified sampling locations were used as planned. All specified samples were collected and all sample containers reached the laboratory intact and properly preserved (when applicable). For all samples, sample temperature was maintained during shipment to the laboratory, and sample chain of custody was maintained during sample storage and/or shipment.

A.4.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one dataset can be compared to another (EPA, 1987). To ensure comparability, the CAU 477 field sampling activities were performed and documented in accordance with approved procedures; a standardized sampling approach and analytical methodology were used; and all samples were collected per the CAIP (DTRA, 1999a). Approved standardized methods and procedures were also used to analyze and report the data (e.g., EPA SW-846, "Methods and Contract Laboratory Program" [CLP] [EPA, 1994a] and/or CLP-like data packages). This approach ensures that the data from this project can be compared to other datasets. Based on the minimum comparability requirements specified in the Industrial Sites QAPP (DOE/NV, 1996), all requirements were met.

Sample-handling documentation, laboratory nonconformance reports, and the precision and accuracy of QC sample results were evaluated for their effect on the results of the associated environmental soil samples. The environmental sample results were then qualified according to processes outlined in the following section. Documentation of the data qualifications resulting from these reviews is retained in project files.

A.4.6 Data Validation

All laboratory data from samples collected at the N-Tunnel Muckpile have been evaluated for data quality according to EPA Functional Guidelines (EPA, 1994a; 1994b). These guidelines were implemented in a tiered process and are presented in the following text. Modifications to the laboratory-generated qualifiers were required to account for estimated values and associated blank contamination. No data rejected during the data evaluation process were used to support the conclusions presented in Section A.3.0. Only detections, whether estimated (i.e., J-qualified) or not, were used in supporting the conclusions.

Changes resulting from the data evaluation process are documented in project files and summarized in memoranda for each sample delivery group (SDG). These memoranda are maintained with the SDGs in the project files.

A.4.6.1 Tier I

Tier I evaluation for chemical analysis examines (but is not limited to):

- Sample count/type consistent with chain of custody
- Analysis count/type consistent with chain of custody
- Correct sample matrix
- Significant problems stated in cover letter or case narrative
- Completeness of certificates of analysis
- Completeness of CLP or CLP-like packages
- Completeness of signatures, dates, and times on chain of custody
- Condition-upon-receipt variance form included
- Requested analyses performed on all samples
- Date received/analyzed given for each sample
- Correct concentration units indicated
- Correct detection limits achieved
- Electronic data transfer supplied
- Results reported for field and laboratory QC samples
- Whether or not the deliverable met the overall objectives of the project

A.4.6.2 Tier II

Tier II evaluation for chemical analysis examines (but is not limited to):

- Sample date, preparation date, and analysis date for each sample
- Holding time criteria met
- QC batch association for each sample
- Cooler temperature upon receipt
- Sample pH for aqueous samples, as required
- Detection limits properly adjusted for dilution, as required
- Blank contamination evaluated and applied to sample results/qualifiers
- Matrix spike/MSD %Rs and RPDs evaluated and applied to laboratory results/qualifiers
- Field duplicate RPDs evaluated and applied to laboratory results/qualifiers
- Laboratory duplicate RPDs evaluated and applied to laboratory results/qualifiers
- Surrogate %Rs evaluated and applied to laboratory results/qualifiers
- Laboratory control sample %Rs evaluated and applied to laboratory results/qualifiers

A.4.6.3 Tier III

Additional data quality considerations included in EPA data review functional guidelines are evaluated as a third party Tier III review. Tier III review of chemical results include the following additional evaluations:

- Mass spectrometer tuning criteria
- Initial and continuing calibration verification
- Internal standard evaluation
- Organic compound quantitation
- Inductively coupled plasma (ICP) interference check sample evaluation
- Graphite furnace atomic absorption QC
- ICP serial dilution effects
- Recalculation of all laboratory results from raw data

Tier I and II data evaluations are summarized in a memorandum for each SDG showing results and qualifiers that were changed and the reason for these changes. Tier III review was performed on at least five percent of the analytical data. A report of the findings has been issued and included in the project files.

A.4.7 Quality Control Samples

Forty-three QC samples (i.e., trip blanks, equipment rinsate blanks, field duplicates, and MS/MSDs) were collected and submitted for laboratory analysis, as shown in Table A.3-1. The blanks and duplicates were assigned individual sample numbers and sent to the laboratory

"blind." Additional samples were selected by the laboratory to be analyzed as laboratory replicates, duplicates, matrix duplicates, and MS/MSDs. Documentation related to the collection and analysis of these samples is retained in project files. The decision was made during the CAI to forego the one in 20 field blank requirement because only soil samples were being collected and using a water matrix for the field blank would not provide a valid comparison. In support of this decision, the equipment rinsate samples were collected in the same area the field blank would have been collected, so they would adequately demonstrate if airborne contaminants were in the sampling area.

A.4.7.1 Field Quality Control Samples

Equipment rinsate blanks were analyzed for the parameters listed on Table A.3-2 (trip blanks were analyzed for VOCs only) and showed contamination associated with common laboratory artifacts (acetone, methylene chloride, and phthalate esters as defined in the EPA Functional Guidelines). These blank detections were used to qualify the results of the associated environmental samples according to EPA Functional Guidelines (EPA, 1994a; 1994b).

According to the EPA Functional Guidelines, no qualification action is taken if a compound is found in an associated blank, but not in the sample, or if a compound is found in the sample, but not in an associated blank. The action taken when a compound is detected in both the sample and the associated blank varies depending upon the analyte involved and is known as "The 5X/10X Rule."

For most VOCs and SVOCs, an analyte detected in the sample above the instrument detection limits, that was also detected in an associated blank, is qualified as undetected (U) if the sample concentration is less than five times (5X) the blank concentration. For the common laboratory contaminants (methylene chloride, acetone, 2-butanone [methyl ethyl ketone], and phthalate esters [especially bis(2-ethylhexyl) phthalate]), the factor is raised to ten times (10X) the blank concentration. The sample result is elevated to the quantitation limit/sample detection limit, if it is not already reported at that level. For inorganics (metals), sample results concentrations detected above the instrument detection limit but less than five times (5X) the amount found in an associated blank are qualified as undetected (U). There are no documented common metallic laboratory contaminants as compared to VOCs and SVOCs, so the sample result is never altered using a "10X rule."

Documentation of the data qualifications resulting from the application of these guidelines is retained in project files as both hard copy and electronic media.

Four field duplicate soil samples were sent as blind samples to the laboratory to be analyzed for the analytical parameters listed in Table A.3-2. For these samples, the duplicate results precision (i.e., RPDs between the environmental sample results and their corresponding field duplicate sample results) were compared to criteria set forth in EPA Functional Guidelines (EPA, 1994a; 1994b), and the associated environmental sample results were qualified accordingly.

The EPA Functional Guidelines give no required review criteria for field duplicate analyses comparability, but allow the data reviewer to exercise professional judgment. Both detections and nondetections are qualified as estimated (J and UJ, respectively) if the RPD between an environmental sample and its field duplicate fall outside established criteria.

Four field samples were selected for use as MS/MSD samples. The %R of these samples (a measure of accuracy) and the RPDs in these sample results (a measure of precision) were compared to EPA Functional Guideline (EPA, 1994a; 1994b) criteria, and the results were used to qualify associated environmental sample results accordingly.

The EPA Functional Guidelines for review of organic data state that no data qualification action is taken on the basis of MS/MSD results alone. The data reviewer exercises professional judgment in considering these results in conjunction with the results of laboratory control samples and other QC criteria in applying qualifiers to the data. Generally, if recovery criteria are greater than the upper acceptance limit, then positive sample results for the affected compounds are qualified as estimated (J), and nondetections are not qualified. If recovery criteria are less than the lower acceptance limit, then positive sample results for the affected compounds are qualified as estimated (J) and nondetections are qualified as unusable (R). The RPD results of MS/MSD samples that fall outside established criteria are applied to qualify detections and nondetections as estimated (J and UJ, respectively).

The EPA Functional Guidelines for inorganic data review allow professional judgment to be applied in evaluating the results of both matrix spikes and laboratory duplicates. Generally, if spike recoveries are greater than the upper acceptance limit or less than the lower acceptance limit, positive results are qualified as estimated (J), and nondetections are either unqualified or qualified as estimated (UJ), respectively. If spike recoveries are grossly low (less than 30 percent), positive results are unqualified, and nondetections are unusable (R). The RPD between

the environmental sample and its laboratory duplicate are compared to established criteria to qualify detections and nondetections as estimated (J and UJ, respectively).

A.4.7.2 Laboratory Quality Control Samples

Analysis of method QC blanks and laboratory control samples was performed for each parameter analyzed by Paragon Analytics, Inc. In addition, laboratory duplicate analysis was performed on several environmental samples per SDG. The results of these analyses were used to qualify associated environmental sample results according to EPA Functional Guidelines (EPA, 1994a; 1994b) as discussed above.

A.4.8 Nonconformances and Field Deficiencies

No laboratory deficiencies were identified for this project. No field deficiencies were identified for this project.

A.5.0 Summary

Analysis of the data generated from sampling activities conducted during corrective action investigation activities conducted at the N-Tunnel Muckpile indicates the following:

- Preliminary action levels were not exceeded for total VOCs or total SVOCs for any of the samples collected at the N-Tunnel Muckpile site.
- One sample (NS-46-13.5) had a lead concentration of 2,040 mg/kg and radioisotopes known to be associated with weapons testing (cobalt-60, cesium-137, plutonium-238, and plutonium-239) at greater than background levels at 13.5 ft bgs. Additional TCLP analysis for the lead indicated that the lead was not leachable above regulatory levels.
- One sample (NS-23-02) had a lead concentration of 59,700 mg/kg and an arsenic concentration of 38.8 mg/kg at 2 ft bgs. Additional TCLP analysis for the lead indicated that the lead was not leachable in detectable quantities.
- Arsenic concentrations were detected above the industrial PRG levels in several samples collected. However, these concentrations were within the range determined to represent the natural arsenic concentrations on the NTS (NBMG, 1998). Based on the background concentrations, it is felt that arsenic is naturally occurring at these levels with the exception noted above.
- One sample (NS-17-36) had radioisotopes known to be associated with weapons testing (plutonium-238 and plutonium-239) greater than background levels at 36 ft bgs.
- TPH-diesel was detected at eight scattered locations near the surface and one location (Borehole 21) at 20 ft bgs.

A.6.0 References

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Appendix B

Data Quality Objectives Process

for

CAU 477, Area 12 N-Tunnel Muckpile

B.1.0 Data Quality Objectives Process for CAU 477, Area 12 N-Tunnel Muckpile

Note: These DQOs were presented in the CAU 477 CAIP issued on January 29, 1999.

The DQO process is a systematic planning tool used to establish criteria for data quality and for developing the N-Tunnel Muckpile data collection program. This iterative, seven-step process results in a design to collect the right type, quality, and amount of data needed to support a course of action for the site. The DQOs were designed to provide a means to determine what type of data needs to be collected, as well as to ensure that the data collected are scientifically sound, defensible, and of known acceptable documented quality and will be used to design a data collection program that will satisfy these goals. The DQOs were revised from those in the NDEP-approved sampling and analysis plan originally prepared for this site (DNA, 1992). The revised DQOs, described in this CAIP, were developed during informal discussions between DTRA and contractor personnel. The main steps include the following:

- Statement of the problem
- Identification of the decision
- Definition of study boundaries
- Determination of decision rules
- Speciation of decision error limits
- Optimization of the design

The seven steps and their application to the N-Tunnel Muckpile are described in the following sections.

B.1.1 Problem Statement

The N-Tunnel Muckpile appears to have been used for the disposal of mining debris (rock) generated during tunnel construction and mining, construction, and radioactive reentry material. The muckpile was used for disposal for approximately 29 years. The N-Tunnel Muckpile contents may contain potentially contaminated material. It is not known if or to what extent contamination exists at this site. Based on the process knowledge, this CAIP recommends that the muckpile be investigated.

B.1.2 Identification of the Decision

The primary decision to be made from this investigation is whether the muckpile contents are hazardous under RCRA, contain TPH contamination levels exceeding the NAC limits, or contain radioactive contamination exceeding background levels.

B.1.3 Identification of Inputs to the Decision

Decisions regarding the sampling approach depend foremost on a reasonable conceptual model (Section B.1.3.1). The model provides a basis for development of the approach and, ultimately, the course of action that will be taken for the site. The conceptual model will be tested by two methods of sampling: random environmental sampling and biased environmental sampling.

The COPCs within the N-Tunnel Muckpile will be evaluated through collection of a combination of random and biased environmental samples from the muckpile surface and near-surface (0 to 5 ft), muckpile subsurface (>5 ft), native soils beneath the muckpile (5 ft below), and the buried retention ponds beneath the muckpile. Sample locations will be field screened for VOCs using a photoionization detector headspace and alpha and beta/gamma emitters using hand-held probes. If contamination is found through the field-screening methods, selected subsurface samples from these "hot spots" will be submitted for off-site laboratory analysis. All environmental samples selected for laboratory analysis will be analyzed for VOCs, SVOCs, TPH-DRO, TPH-GRO, RCRA metals, and/or radionuclides. The methods for field screening and off-site laboratory analysis will have detection limits below preliminary action levels, in addition, background native soil samples will be collected and field screened for alpha and beta/gamma emitters using a hand-held probe. Background samples will be submitted for off-site laboratory analysis for RCRA metals and radionuclides.

B.1.3.1 Conceptual Site Model

A conceptual model has been developed to postulate potential exposure pathways from likely contaminant sources at the N-Tunnel Muckpile. If the conceptual model is proven incorrect from the results of environmental sampling, then the NDEP will be notified and the CAI rescoped. The following statements are assumptions and/or facts that were considered regarding the N-Tunnel Muckpile:

- The muckpile was developed on basal Tertiary tuffs overlying Devonian carbonates that extend along the base of Rainier Mesa. Material underlying the muckpile are believed to be mostly alluvial, but bedrock exposures are possible.

- The N-Tunnel Muckpile consists of mining debris (uncontaminated rock) generated during the excavation phase of tunnel construction. Only 1 percent is thought to be reentry (i.e., post-event) construction debris (DNA, 1990).

- Muckpile thickness ranges from approximately 10 ft near the tunnel portals to approximately 120 ft near the center of the muckpile.

- There are eight distinct lobes of debris material that make up the muckpile; each lobe can be tied to a group of specific test events within a range of specific dates. Post-event debris may include disturbed geologic materials and construction/reentry debris. There is no specific information about the variations in contents of the lobes as they apply to nuclear tests.

- Detailed analyses of the N-Tunnel host rock chemistry indicate naturally occurring metals (e.g., 20 to 50 parts per million lead).

- The muckpile may contain low-level radioactive waste (fission and activation products), but the exact distribution and location are unknown. There is assumed to be negligible radioactive contamination on the muckpile surface and in the shallow subsurface (3 to 5 ft).

- The muckpile may contain RCRA hazardous wastes, including lead and cement grouts, although there is no positive evidence verifying disposal of hazardous or RCRA materials in the muckpile. The muckpile probably received little free liquid wastes.

- The muckpile was developed without a liner at its base. Although specific permeability data are lacking, low precipitation and high evaporation rates at the base of Rainier Mesa would tend to constrain downward migration of contaminants within the muckpile. Most mining debris consists of zeolitized tuffaceous rock, which could also inhibit downward migration of liquid.

- Surface occupancy activities included hazardous materials use, hazardous waste storage, and petroleum use, storage, and release. Releases to the muckpile from surface activities may be locally significant, but vertical infiltration of contaminants is probably shallow (3 to 5 ft).

- The most viable pathway for migration of contaminants from the muckpile is by percolation of water at the perimeter of the muckpile and downward through the muckpile fill to the underlying alluvium.

- Possible future uses of the muckpile area may include surface activities which have the potential to intrude into the near-surface muckpile materials to a depth of 3 to 7 ft.

Using these assumptions, a CSM was developed (Figure B.1-1). It was postulated that the majority of the muckpile does not contain COPCs, and any COPCs that are present are probably

located in isolated surface or subsurface "hotspots." The most likely affected areas are the surface and shallow subsurface where use of petroleum compounds related to tunnel equipment maintenance activities near the tunnel portals may have resulted in releases to the environment. These releases, if present, are anticipated to have limited lateral and vertical migration potential. It is also possible, but unlikely, that an impact to the native soils beneath the muckpile has occurred from downward migration of COPCs.

B.1.4 Definition of Study Boundaries

The physical boundaries of the study area are defined in the *x* and *y* dimensions by the areal extent of the N-Tunnel Muckpile as interpreted from aerial photographs (Bedsun, 1997). In the *z* dimension, the study area includes the native soils and buried pond sediments to a depth of 5 ft below the muckpile bottom. The study area also includes background sample locations outside, but adjacent to, the spatial boundaries of the muckpile.

The constraint of this study is encountering material that may limit the depth of investigation.

B.1.5 Determination of Decision Rules

The results of the laboratory analytical data will provide information to assist in determining the need for further action at this site. Further action may be needed if identified COPCs are above the following action levels:

- 100 mg/kg TPH in soil, per the "Water Controls" (NAC, 1996).
- U.S. Environmental Protection Agency (EPA) Region 9 Preliminary Remediation Goals (PRGs) (EPA, 1998) for industrial soils.

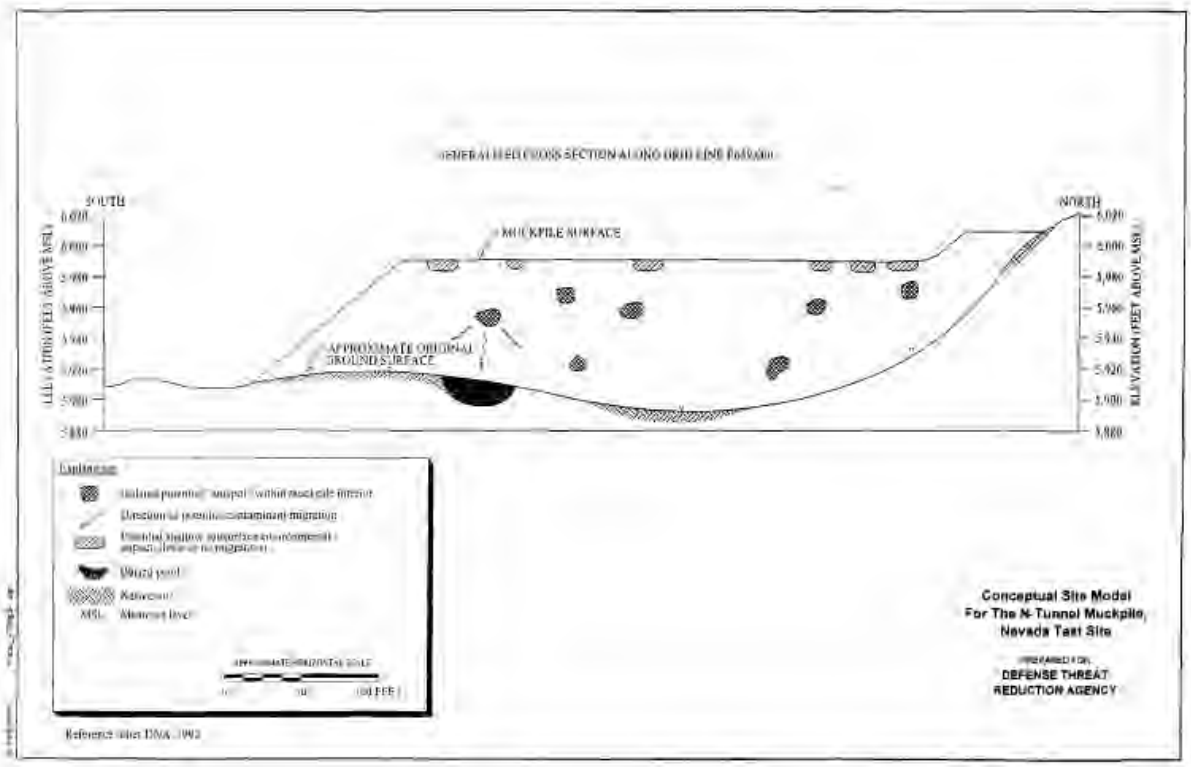

Figure B.1-1
CAU 477 Conceptual Site Model

- Isotopic or total activities above background levels or the levels listed in the *Offsite Radiation Exposure Review Project (ORERP), Phase II Soils Programs* report (McArthur and Miller, 1989).

For any COPCs not described above, site-specific concentration limits will be derived per the proposed RCRA Subpart S rules for corrective actions (Federal Register, 1990).

B.1.6 Specification on Decision Error Limits

The baseline condition, or null hypothesis, assumed for this site is that COPCs above action levels will be identified in the muckpile. The alternate hypothesis is that COPCs above action levels will not be identified. Based on these hypotheses, there are two types of decision errors possible in implementing this CAIP. These errors are described as a false positive and a false negative. This CAIP has been designed to minimize both types of errors.

The consequences of a false positive are that (1) corrective action activities could encompass a greater quantity of media than is necessary, and (2) media incorrectly judged to be contaminated could be disposed of as regulated waste instead of unregulated waste. Both of these consequences could lead to increased corrective action and waste disposal costs.

The consequences of a false negative are that (1) regulated contaminants might not be appropriately addressed by corrective action or treatment activities; (2) contamination could remain in place; and (3) contaminated media might be disposed of improperly. These consequences could lead to unacceptable risks to human health and the environment and to potential fines from regulatory agencies.

The sampling program for the N-Tunnel Muckpile CAU was designed to provide preliminary data to allow statistical determination of whether enough samples were collected to sufficiently characterize the site. The determination will be made using procedures described in Chapter 9 of the EPA publication SW-846, Test Methods for Evaluating Solid Waste (EPA, 1986). The mean concentration (or activity) and standard deviation of each targeted analyte in the muckpile soils was used to calculate the number of samples necessary to make the determination with a 90 percent confidence level. Based on the existing information about the likely COPCs in the muckpile material (DNA, 1992), the calculations estimated that 30 random muckpile subsurface borehole samples would be sufficient for the initial statistical determination, this does not include sample locations identified based on field screening results. The random samples will be collected at locations based on random number tables (DNA, 1992; Appendix D) to ensure a nonbiased, overall sampling approach for the muckpile. Additionally, 30 random soil samples below the muckpile/native soil interface, five buried pond sediment samples, 13 muckpile surface samples, and three background samples will be collected.

B.1.7 Optimization of Design for Obtaining Data

The sampling program has been optimized by determining the location and number of samples to collect, and by determining which parameters should be analyzed. The COPCs are TPH, VOCs, SVOCs, RCRA metals, and radionuclides. All environmental samples, with the exception of the three background samples, which will be analyzed for radionuclides and RCRA metals), will be analyzed for these parameters. Field screening will be used to identify samples that contain VOCs and/or radionuclides, and screening results will guide the determination of samples to be selected for off-site laboratory analysis.

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Appendix C

Data Assessment

C.1.0 Data Assessment

The DQA process is the scientific evaluation of the investigation results to determine whether the DQO criteria established in the CAU 477 CAIP were met and whether the DQO decisions can be supported at the desired level of confidence. The DQO process ensures that the right type, quality, and quantity of data will be available to support the resolution of the decisions at an appropriate level of confidence. Using both the DQO and DQA processes helps to ensure that the DQO decisions are sound and defensible, and that the 90 percent level of confidence agreed to in the CAIP was achieved.

The DQA involves five steps that begin with a review of the DQOs and end with an answer to the DQO decisions. The five steps are briefly summarized below.

Step 1: Review the DQOs and Sampling Design – Review the DQO process to provide context for analyzing the data. State the primary statistical hypotheses; confirm the limits on the decision errors for committing false rejection (Type I) or false acceptance (Type II) decision errors; and review any special features, potential problems, or deviations to the sampling design.

Step 2: Conduct a Preliminary Data Review – The preliminary data review involves reviewing QA reports and inspecting the data both numerically and graphically, validating and verifying the data to ensure that the measurement systems performed in accordance with the criteria specified, and using the validated data to determine whether the quality of the data is satisfactory.

Step 3: Select the Test – Select the test based on the population of interest, population parameter, and the hypotheses. Identify the key underlying assumptions that could cause a change in one of the DQO decisions.

Step 4: Verify the Assumptions – Perform tests of assumptions. If data are missing or are censored, determine the impact on the DQO decision error.

Step 5: Draw Conclusions from the Data – Perform the calculations required for the test.

C.1.1 Review the DQOs and Sampling Design

This section contains a review of the DQO process presented in the CAU 477 CAIP (DTRA, 1999) and Appendix B of this document. The DQO decisions are presented with the DQO provisions for limiting false negative or false positive decision errors. Special features, potential problems, or any deviations from the sampling design are also presented.

C.1.1.1 Review DQOs

The decision statement as presented in the CAU 477 CAIP is: "Are the muckpile contents hazardous under RCRA, contain TPH contamination at levels exceeding the NAC limits, or contain radioactive contamination exceeding background levels?"

DQO Provisions To Limit False Negative Decision Error

A false negative decision error (where consequences are more severe) was controlled by meeting the following criteria:

1. Having a high degree of confidence that the combination of random and biased sampling strategies will identify COCs if present in the CASs.
2. Having a high degree of confidence that analyses conducted will be sufficient to detect any COCs present in the samples.
3. Having a high degree of confidence that the data are of sufficient quality and completeness.

Criterion 1:

The following methods (stipulated in the CAU 477 DQOs [DTRA, 1999]) were used in selecting the sample locations:

- Random locations to collect deep subsurface soil samples.
- Biased locations based on professional judgment and site knowledge to collect pond sediment samples and shallow subsurface soil samples.

This provides a high degree of confidence that sampling will detect any COCs that may be present using the analytical results, and the EPA guidance confirmed that the proposed number of samples was sufficient to characterize the muckpile.

Criteria 2:

All samples were analyzed using the analytical methods listed in Table 3-1 of the CAIP. Table C.1-1 provides a reconciliation of environmental samples analyzed to the planned analytical program. Samples were analyzed for all of the analytical methods specified in the CAIP (DTRA, 1999).

Table C.1-1
CAU 477 Number of Soil Samples Submitted per Analyte

	ANALYTES						
	VOCs	SVOCs	TPH-DRO	TPH-GRO	Metals	Alpha for Waste Management	Gamma Spectroscopy
Muck	39	39	39	39	39	2	39
Native Soil	37	37	37	37	37	2	37
Shallow	13	13	13	13	13	0	13
Pond Sediment	3	3	3	3	3	0	3
Background	0	0	0	0	3	0	3

Sample results were assessed against the DQI of sensitivity as defined in the Industrial Sites QAPP (NNSA/NV, 2002). The CAU 477 corrective action conducted following the quality requirements in the Industrial Sites QAPP dated 1996; however, this is superseded by the Industrial Sites QAPP dated 2002. This CADD/CR will be written following the requirements in the 2002 Industrial Sites QAPP. The sensitivity acceptance criteria defined in the CAIP is that analytical detection limits will be less than the corresponding action level. This goal was not achieved for the chemical analyses listed in Table C.1-2. All radiological analytes met the sensitivity goal. Results not meeting the sensitivity goal were not used in making DQO decisions and will therefore be considered as rejected data.

Table C.1-2
Chemical Analytes Failing Sensitivity Criteria for CAU 477

Sample Number	Parameter	Result (µg/kg)	Detection Limit (µg/kg)	1998 Industrial PRG (µg/kg)
NS-12-78	N-Nitrosodimethylamine	380	180	34
NS-12-66	N-Nitrosodimethylamine	400	180	34
NS-02-57	N-Nitrosodimethylamine	390	180	34
NS-02-26	N-Nitrosodimethylamine	420	180	34
NS-02-19	N-Nitrosodimethylamine	420	180	34
NS-C-94	N-Nitrosodimethylamine	780	180	34

PRG = Preliminary remediation goal
µg/kg = Micrograms per kilogram

Criterion 3:

To satisfy the third criterion, the entire dataset, as well as individual sample results, were assessed against the acceptance criteria for the DQIs of precision, accuracy, comparability, completeness, and representativeness, as defined in the Industrial Sites QAPP

(NNSA/NV, 2002). The DQI acceptance criteria for precision and accuracy are defined in Table 3-1 of the CAIP (DTRA, 1999). The acceptance criteria for comparability, completeness, and representativeness are not specified in the CAIP. As presented in the following sections, these goals were met for each DQI except as noted.

Precision

The duplicate precision is evaluated using the relative percent difference (RPD) or normalized difference. For the purpose of determining the data precision of chemical analyses, the RPD between duplicate analyses was calculated. For radionuclides, the RPD was not calculated unless both the sample and its duplicate had a concentration of the target radionuclide exceeding five times their minimum detectable concentration. Otherwise, radionuclide duplicate results were evaluated using the normalized difference. Table C.1-3 provides the precision analysis results for all constituents that were qualified for precision. No radionuclides were qualified for precision.

Table C.1-3
Precision Measurements

Parameter	CAS Number	User Test Panel	Number of Analyses Qualified	Number of Measurements Performed	Percent within Criteria
Mercury	7439-97-6	EPA 7471A	4	91	95.6
Barium	7440-39-3	EPA 6010B	14	91	84.6
Lead	7439-92-1	EPA 6010B	14	91	84.6
Arsenic	7440-38-2	EPA 6010B	53	91	41.8
Chromium	7440-47-3	EPA 6010B	58	91	36.3

CAS = Chemical Abstract Number
EPA = U.S. Environmental Protection Agency, SW 846 methods (EPA, 1999 and 2002)

As shown in Table C.1-3, the precision rate for arsenic and chromium were below the acceptance criterion of 80 percent. The precision rate for all of the constituents not listed in the table is 100 percent. The precision goal for both arsenic and chromium is greater than 80 percent within criteria. One sample had an arsenic concentration that exceeded the PAL of 27 mg/kg (NS-23-02, 38.8 mg/kg); however, it did not exceeded the FAL (see Appendix D) of 242 mg/kg. There is negligible potential for a false negative DQO decision error for the arsenic and chromium because the highest reported values are still small in comparison to the FAL. For arsenic, the highest concentration (38.8 mg/kg) is six times less than the FAL (242 mg/kg), and for chromium, the highest concentration (32 mg/kg) is 14 times less than the FAL (450 mg/kg).

Therefore, the arsenic and chromium results that were qualified for precision can be confidently used to support DQO decisions. Because all of the other constituents exceed the acceptance criteria for precision, the dataset is determined to be acceptable for the DQI of precision.

Accuracy

For the purpose of determining data accuracy of sample analyses, environmental soil samples were evaluated and incorporated into the accuracy calculation. The results qualified for accuracy were associated with laboratory control samples (LCSs) exceeding control limits and could potentially be reported at concentrations lower or higher than actual concentration. Table C.1-4 provides the evaluation results for the constituents qualified for accuracy.

Table C.1-4
Accuracy Measurements
(Page 1 of 3)

Parameter	CAS Number	User Test Panel	Number of Analyses Qualified	Number of Measurements Performed	Percent within Criteria
2-Chloroethyl Vinyl Ether	110-75-8	VOCs	1	88	98.9
Chromium	7440-47-3	RCRA Metals	1	91	98.9
1,1,1,2-Tetrachloroethane	630-20-6	VOCs	2	88	97.7
1,1,1-Trichloroethane	71-55-6	VOCs	2	88	97.7
1,1,2,2-Tetrachloroethane	79-34-5	VOCs	2	88	97.7
1,1,2-Trichloroethane	79-00-5	VOCs	2	88	97.7
1,1-Dichloroethane	75-34-3	VOCs	2	88	97.7
1,1-Dichloroethene	75-35-4	VOCs	2	88	97.7
1,1-Dichloropropene	563-58-6	VOCs	2	88	97.7
1,2,3-Trichlorobenzene	87-61-6	VOCs	2	88	97.7
1,2,3-Trichloropropane	96-18-4	VOCs	2	88	97.7
1,2,4-Trichlorobenzene	120-82-1	SVOCs	2	88	97.7
1,2,4-Trichlorobenzene	120-82-1	VOCs	2	88	97.7
1,2-Dibromo-3-Chloropropane	96-12-8	VOCs	2	88	97.7
1,2-Dibromoethane	106-93-4	VOCs	2	88	97.7
1,2-Dichlorobenzene	95-50-1	SVOCs	2	88	97.7
1,2-Dichlorobenzene	95-50-1	VOCs	2	88	97.7
1,2-Dichloroethane	107-06-2	VOCs	2	88	97.7
1,2-Dichloropropane	78-87-5	VOCs	2	88	97.7
1,3-Dichlorobenzene	541-73-1	SVOCs	2	88	97.7
1,3-Dichlorobenzene	541-73-1	VOCs	2	88	97.7
1,3-Dichloropropane	142-28-9	VOCs	2	88	97.7
1,4-Dichlorobenzene	106-46-7	SVOCs	2	88	97.7
1,4-Dichlorobenzene	106-46-7	VOCs	2	88	97.7

Table C.1-4
Accuracy Measurements
(Page 2 of 3)

Parameter	CAS Number	User Test Panel	Number of Analyses Qualified	Number of Measurements Performed	Percent within Criteria
1-Chlorohexane	544-10-5	VOCs	2	88	97.7
2,2-Dichloropropane	594-20-7	VOCs	2	88	97.7
2-Chlorotoluene	95-49-8	VOCs	2	88	97.7
2-Hexanone	591-78-6	VOCs	2	88	97.7
4-Chlorotoluene	106-43-4	VOCs	2	88	97.7
4-Methyl-2-Pentanone	108-10-1	VOCs	2	88	97.7
Acrolein	107-02-8	VOCs	2	88	97.7
Acrylonitrile	107-13-1	VOCs	2	88	97.7
Benzene	71-43-2	VOCs	2	88	97.7
Bis(2-ethylhexyl)phthalate	117-81-7	SVOCs	2	88	97.7
Bromobenzene	108-86-1	VOCs	2	88	97.7
Bromochloromethane	74-97-5	VOCs	2	88	97.7
Bromodichloromethane	75-27-4	VOCs	2	88	97.7
Bromoform	75-25-2	VOCs	2	88	97.7
Bromomethane	74-83-9	VOCs	2	88	97.7
Carbon Disulfide	75-15-0	VOCs	2	88	97.7
Carbon Tetrachloride	56-23-5	VOCs	2	88	97.7
Chlorobenzene	108-90-7	VOCs	2	88	97.7
Chloroethane	75-00-3	VOCs	2	88	97.7
Chloroform	67-66-3	VOCs	2	88	97.7
Chloromethane	74-87-3	VOCs	2	88	97.7
Cis-1,2-Dichloroethene	156-59-2	VOCs	2	88	97.7
Cis-1,3-Dichloropropene	10061-01-5	VOCs	2	88	97.7
Dibromochloromethane	124-48-1	VOCs	2	88	97.7
Dibromomethane	74-95-3	VOCs	2	88	97.7
Dichlorodifluoromethane	75-71-8	VOCs	2	88	97.7
Hexachlorobutadiene	87-68-3	SVOCs	2	88	97.7
Hexachlorobutadiene	87-68-3	VOCs	2	88	97.7
Iodomethane	74-88-4	VOCs	2	88	97.7
Methyl Tertiary Butyl Ether	1634-04-4	VOCs	2	88	97.7
Styrene	100-42-5	VOCs	2	88	97.7
Tert-butylbenzene	98-06-6	VOCs	2	88	97.7
Tetrachloroethene	127-18-4	VOCs	2	88	97.7
Trans-1,2-Dichloroethene	156-60-5	VOCs	2	88	97.7
Trans-1,3-Dichloropropene	10061-02-6	VOCs	2	88	97.7
Trichloroethene	79-01-6	VOCs	2	88	97.7

Table C.1-4
Accuracy Measurements
(Page 3 of 3)

Parameter	CAS Number	User Test Panel	Number of Analyses Qualified	Number of Measurements Performed	Percent within Criteria
Trichlorofluoromethane	75-69-4	VOCs	2	88	97.7
Trichlorotrifluoroethane	76-13-1	VOCs	2	88	97.7
Vinylacetate	108-05-4	VOCs	2	88	97.7
Vinyl Chloride	75-01-4	VOCs	2	88	97.7
1,2,4-Trimethylbenzene	95-63-6	VOCs	3	88	96.6
1,3,5-Trimethylbenzene	108-67-8	VOCs	3	88	96.6
Benzo(g,h,i)perylene	191-24-2	SVOCs	3	88	96.6
Isopropylbenzene	98-82-8	VOCs	3	88	96.6
N-Butylbenzene	104-51-8	VOCs	3	88	96.6
N-Propylbenzene	103-65-1	VOCs	3	88	96.6
Naphthalene	91-20-3	SVOCs	3	88	96.6
Naphthalene	91-20-3	VOCs	3	88	96.6
P-Isopropyltoluene	99-87-6	VOCs	3	88	96.6
Sec-Butylbenzene	135-98-8	VOCs	3	88	96.6
Toluene	108-88-3	VOCs	3	88	96.6
2-Butanone	78-93-3	VOCs	4	88	95.5
Ethylbenzene	100-41-4	VOCs	4	88	95.5
M+P-Xylene	136777-61-2	VOCs	4	88	95.5
O-Xylene	95-47-6	VOCs	4	88	95.5
Acetone	67-64-1	VOCs	5	88	94.3
Diesel-Range Organics	68334-30-5	DRO	7	91	92.3
Methylene Chloride	75-09-2	VOCs	7	88	92.0
Dimethyl Phthalate	131-11-3	SVOCs	8	88	90.9
4-Chloro-3-methylphenol	59-50-7	SVOCs	9	88	89.9

As the accuracy rate for all of the constituents exceeds the acceptance criteria, the dataset is determined to be acceptable for the DQI of accuracy.

Representativeness

The DQO process as identified in Section 3.0 of the CAU 477 CAIP (DTRA, 1999) was used to address sampling and analytical requirements for CAU 477. During this process, appropriate locations were selected that enabled the samples collected to be representative of the population parameters identified in the DQO (random locations and biased locations that were most likely to encounter contamination). The sampling locations identified in the Criterion 1 discussion meet

these criteria. Therefore, the analytical data acquired during the CAU 477 CAI are considered to be representative of the population parameters.

Comparability

Field sampling, as described in the CAU 477 CAIP (DTRA, 1999), was performed and documented in accordance with approved procedures that are comparable to standard industry practices. Approved analytical methods and procedures were used to analyze, report, and validate the data. These are comparable to other methods used not only in industry and government practices, but most importantly are comparable to other investigations conducted at the NTS. Therefore, project datasets are considered comparable to other datasets generated using these same standardized DOE procedures, thereby meeting the DQO requirements. Also, standard, approved field and analytical methods ensure that data were appropriate for comparison to the investigation action levels specified in the CAIP (DTRA, 1999).

Completeness

The CAU 477 CAIP did not define criteria for completeness so the criteria of 80 percent of CAS-specific non-critical analytes identified in the CAIP having valid results and 100 percent of critical analytes having valid results will be used for the CAU 477 evaluation. Also, the dataset must be sufficiently complete to be able to support the DQO decisions. Critical analytes for CAU 477 were not defined so the COCs identified from other investigated NTS muckpiles (arsenic, lead, TPH-DRO, plutonium [Pu]-239, cesium [Cs]-137, and cobalt [Co]-60) have been defined as the critical analytes for CAU 477 with the exception of Pu-239. Plutonium was not expected at CAU 477, so the samples were not analyzed for plutonium except for two samples that were analyzed for waste management purposes.

Rejected data (either qualified as rejected or data that failed the criterion of sensitivity) were not used in the resolution of DQO decisions and are not counted toward meeting the completeness acceptance criterion. Table C.1-5 shows the data rejected because of completeness. None of the rejected data are critical analytes, and all of the qualified data except N-nitrosodimethylamine exceed the 80 percent criteria for completeness. The N-nitrosodimethylamine samples were rejected because calibration verification was not done or did not meet criteria. This results in a determination that the N-nitrosodimethylamine may or may not be present. However, because N-nitrosodimethylamine was not found in any of the samples that were not rejected and the site will be closed with use restrictions, the rejected data for N-nitrosodimethylamine will not affect the DQO decisions. Because all other chemical and radiological data exceed the criteria, the dataset is considered complete for purposes of supporting the DQO decisions.

Table C.1-5
Rejected Measurements for Completeness

Parameter	CAS Number	User Test Panel	Number of Analyses Qualified	Number of Measurements Performed	Percent within Criteria
Acetone	67-64-1	EPA 8260	8	88	90.9
2-Chloroethyl Vinyl Ether	110-75-8	EPA 8260	6	88	93.2
Pyridine	110-86-1	EPA 8270	14	88	84.1
N-Nitrosodimethylamine	62-75-9	EPA 8270	39	88	55.7

DQO Provisions To Limit False Positive Decision Error

The false positive decision error was controlled by assessing the potential for false positive analytical results. Quality assurance (QA)/quality control (QC) samples such as field blanks, trip blanks, LCSs, and method blanks were used to determine whether a false positive analytical result may have occurred. Of the 47 QA/QC samples submitted, no false positive analytical results were detected.

Proper decontamination of sampling equipment and the use of certified clean sampling equipment and containers minimized the potential for cross contamination that could lead to a false positive analytical result.

C.1.1.2 Sampling Design

The CAIP (DTRA, 1999) made the following commitments for sampling:

1. Random sampling was conducted on the muckpile.

   Result: Thirty-three of the 50 random locations identified were drilled and sampled. Fifty locations were identified to ensure there would be enough random locations in case some of the original locations could not be drilled.

2. Biased locations were identified and drilled to attempt to intersect and sample the ponds buried by the muckpile.

   Result: Four biased locations were identified and drilled. Two of the holes intersected the ponds and sediment samples were collected, the other two holes did not intersect pond sediments. In addition, one random hole intersected pond sediments and a sample was collected.

3. Biased locations were identified and drilled to investigate the shallow subsurface in areas suspected of being contaminated.

   Result: Thirteen biased locations were identified and drilled to 5 ft to investigate the potentially contaminated areas.

C.1.2 Conduct a Preliminary Data Review

A preliminary data review was conducted by reviewing QA reports and inspecting the data. The contract analytical laboratories generate a QA non-conformance report when data quality does not meet contractual requirements. All data received from the analytical laboratories met contractual requirements, and no QA non-conformance reports were generated. Data were validated and verified to ensure that the measurement systems performed in accordance with the criteria specified. The validated dataset quality was found to be satisfactory.

C.1.3 Select the Test

The CAIP (DTRA, 1999) committed to using the procedure described in Chapter 9 of the EPA SW-846 Method (EPA, 1999) to answer two questions: 1) Were enough samples collected to ensure a 90 percent confidence level in the mean COPC concentration and 2) Does the mean concentration exceed the regulatory threshold?

Because of the change in closure strategy agreed to by NDEP, DTRA, and DOE, National Nuclear Security Administration Nevada Site Office (NNSA/NSO), the regulatory threshold is now the risk-based FAL instead of the PALs discussed in the CAIP. Comparing the average concentration of the most prevalent contaminants to their PAL and, if they exceed the PAL, comparing them to their respective FALs will also be used to help answer the questions.

C.1.4 SW-846 Evaluation

To answer the first question, equation (8) of Table 9-1 in SW 846 was used. To answer the second question, equation (6) of Table 9-1 in SW-846 was used (EPA, 1999). Only random samples were used for this evaluation. These questions were answered for the critical analytes (Cs-137, Co-60, TPH-DRO, arsenic, and lead).

Question 1: Were enough samples collected is answered by solving equation (8) of Table 9-1 in SW-846 for each analyte.

$$n = t_{.20}^2 \times s^2 / (RT - \bar{x})^2 \qquad \text{where} \qquad (\textit{Equation 1})$$

n = minimum number of samples to ensure a 90 percent confidence level

$t_{.20}^2$ = the square of the "t" value in Table 9-2, SW-846 for a one-tailed 90 percent confidence interval

s^2 = variance in the concentration measured in the samples collected during characterization

RT = regulatory threshold and is set to the limiting PRG established by the EPA for the COPC for the industrial land use. For TPH, the RT is 100 mg/kg. For radionuclides, it is the U.S. Nuclear Regulatory Commission and National Council on Radiation Protection and Measurements screening levels

$\bar{x}$ = the mean concentration of the COPC in the collected samples.

Question 2: Does the mean concentration exceed the regulatory threshold is answered by solving equation (6) of Table 9-1 in SW-846 for each analyte.

$$CI = \bar{x} +/- (t_{.20} \times (\frac{s}{\sqrt{n}})) \qquad \text{where} \qquad (\textit{Equation 2})$$

CI = confidence interval

$\bar{x}$ = the mean concentration of the COPC in the collected samples

n = number of samples collected

$t_{.20}$ = the "t" value in Table 9-2, SW-846 for a one-tailed 90 percent confidence interval and
the appropriate degrees of freedom

$s_{\bar{x}}$ = variance in the concentration measured in the samples collected during characterization

The values used for the calculations and the results are presented in Table C.1-6.

Table C.1-6
SW-846 Evaluation of the Number of Samples and Comparison of 90% Confidence Level with the PAL

Variable	Cs-137	Co-60	TPH-DRO	Arsenic	Lead
$T_{.20}$	1.308	1.31	1.308	1.309	1.308
$T_{.20}^2$	1.711	1.716	1.711	1.713	1.711
S^2	1.814 E-01	3.788 E-04	2,083.321	39.484	1.08 E08
RT	7.3 pCi/g	2.7 pCi/g	100 mg/kg	23 mg/kg	800 mg/kg
Avg $\bar{x}$	2.356 E-01 pCi/g	8.297 E-02 pCi/g	30.579 mg/kg	4.84375 mg/kg	1,825 mg/kg
n collected	34	32	32	32	33
n needed	<1	<1	<1	<1	176
Confidence Interval	9.555 E-02	4.507 E-03	10.554	1.454	2,365.625
90% Confidence	3.312 E-01 pCi/g	8.748 E-02 pCi/g	41.133 mg/kg	6.298 mg/kg	4,191.028 mg/kg
90%Confidence>RT	No	No	No	No	Yes

Based on the results of the calculations, an adequate number of samples was collected to meet the 90 percent confidence level for characterization of the site for all of the critical analytes except for lead. In comparing the 90 percent confidence level to the PAL, the confidence level for lead exceeds the PAL in the muckpile. The high value for lead is caused by one sample, NS-23-02, which had a lead level of 59,700 mg/kg. This sample was collected at a depth of 1 to 2 ft. near the N-Tunnel portal in an area where lead shot was observed on the ground. It is assumed that the high result is caused by a piece of the shot in the sample. In addition, a TCLP analysis was conducted on that sample which showed that the lead was not leachable in detectable quantities. If that sample is removed, equation (1) shows that less than one sample is needed to achieve the 90 percent confidence level, and equation (2) shows that the CI for the 90 percent confidence level is 19 mg/kg, which is below the PAL of 800 mg/kg.

C.1.5 Verify the Assumptions

The results of the investigation support the assumptions identified in the CAU 477 DQOs and in Table C.1-7.

Table C.1-7
Key Assumptions

Exposure Scenario	Exposure to contaminants is limited to industrial site workers, construction/remediation workers, and military personnel conducting training. Exposure could occur through ingestion, inhalation, external exposure, or dermal contact.
	The investigation did not reveal any potential exposures that were not identified in the conceptual site model (CSM).
Affected Media	Surface and subsurface soils in and below the muckpile. Contamination of perched, deep, and regional groundwater is not a concern.
	The investigation results did not identify any affected media that was not identified in the CSM.
Location of Contamination Release Points	The muckpile may contain small volumes of RCRA-regulated constituents in addition to radiological constituents.
	The investigation results confirmed this and did not reveal any potential releases off the muckpile.
Transport Mechanisms	Contamination may migrate through the muckpile into the native material as a result of rainwater infiltration.
	The investigation results confirmed there was no transport through the muckpile into the native material.
Preferential Pathways	Percolation of precipitation through the soils of the muckpile.
	The investigation did not identify any contaminant migration through the muckpile.
Lateral and Vertical Extent of Contamination	Contamination could be locally significant, but vertical infiltration of contaminants is probably limited to less than 5 feet.
	The investigation results confirmed this. Vertical extent was confined to the muckpile; no migration into the native material below the muckpile was found. Lateral extend was also confined to the muckpile.
Groundwater Impacts	There are no groundwater impacts.
Future Land Use	Nonresidential, zoned for nuclear and high explosives tests.
	The investigation results did not reveal any future land uses other than those identified in the CSM.

C.1.6 Results

This section resolves the DQO decision for CAU 477. No decision rules were stated as "if/then" statements in the DQOs. However, the following "if/then" statement can be assumed from the DQOs.

C.1.6.1 Decision Rules for CAU 477

Decision Rule: If COPCs are above the PALs, then further action may be needed.

Result: Because the site was characterized and a CADD was prepared, the DOE and NDEP came to an agreement that a risk-based approach could be used for characterizing the muckpiles. Because of this decision, NDEP agreed to allow existing muckpile CADDs that had been approved by NDEP to be re-evaluated using the risk-based approach. Using the risk-based approach for limited access industrial reuse scenario, FALs were not exceeded except for lead.

C.2.0 References

DTRA, see Defense Threat Reduction Agency.

Defense Threat Reduction Agency. 1999. *Corrective Action Investigation Plan for Corrective Action Unit 477: N-Tunnel Muckpile, Nevada Test Site*. Rev. 0. January.

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Appendix D

Risk Assessment for CAU 477

D.1.0 Risk-Based Corrective Action Process

This section contains documentation of the ASTM Method E 1739-95 (ASTM, 1995) risk-based corrective action process as applied to CAU 477. The ASTM Method E 1739-95 defines three tiers or levels in evaluating DQO decisions involving increasingly more sophisticated analyses.

- Tier 1 – Sample results from source areas (highest concentrations) compared to the PALs based on generic (non-site-specific) conditions.
- Tier 2 – Sample results from exposure points compared to SSTLs calculated using site-specific inputs and Tier I formulas (from the ASTM procedure).
- Tier 3 – Sample results from exposure points compared to SSTLs and points of compliance calculated using chemical fate/transport and probabilistic modeling.

The risk based corrective action decision process stipulated in ASTM Method E 1739-95 is summarized in Figure D.1-1.

D.1.1 Scenario

Corrective Action Unit 477 consists of one CAS.

- CAS 12-06-03, N-Tunnel Muckpile

The muckpile is associated with the N-Tunnel, which was mined into bedded ash flow tuff under Rainier Mesa. The tunnel was used for 21 nuclear tests between 1967 and 1992, and one high explosive test in 1993. The muckpile consists of 296,300 yd^3 of material mined from the tunnel both during initial construction and re-entry operations following tests.

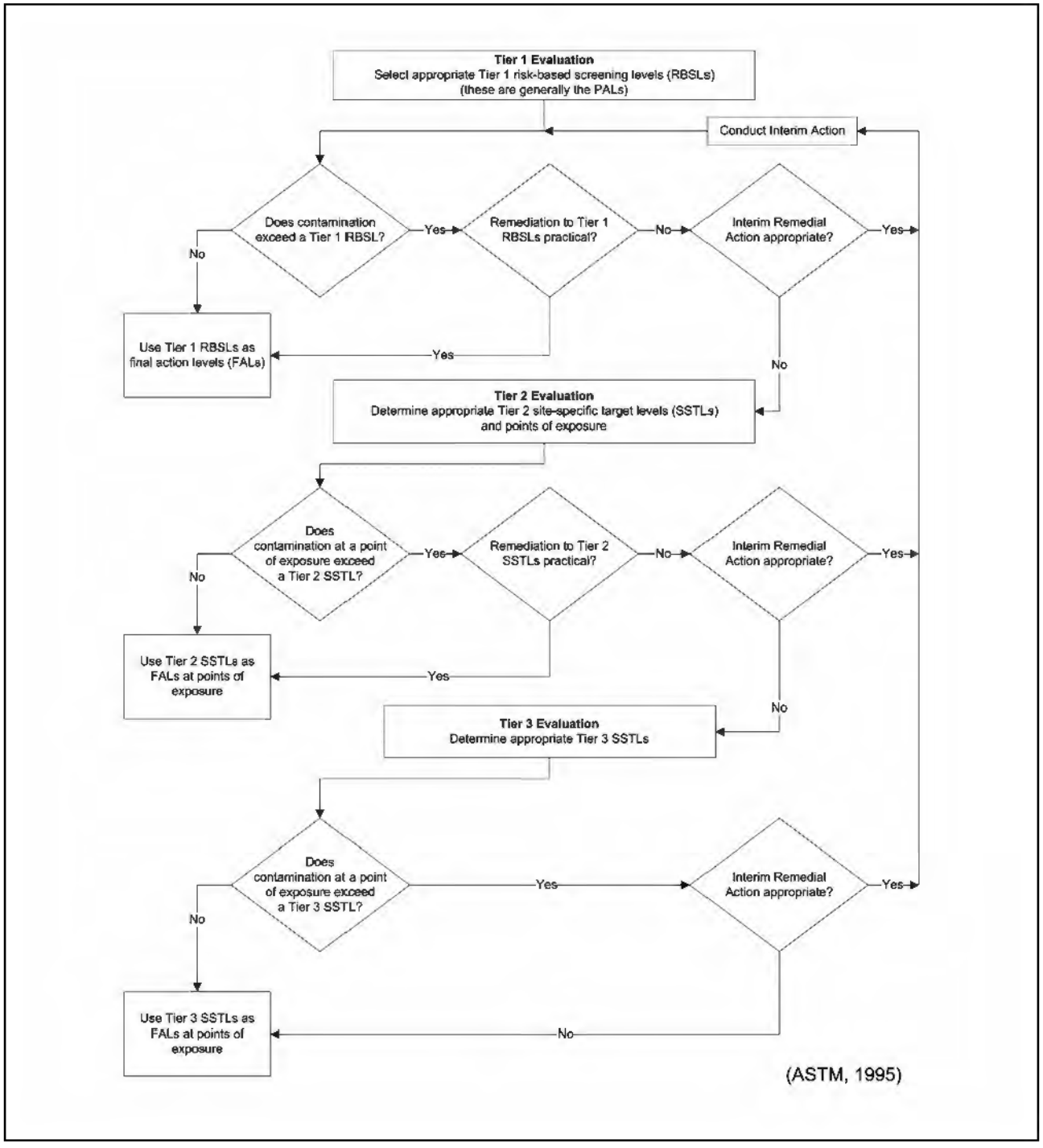

Figure D.1-1
ASTM Method E 1739-95 Risk-Based Corrective Action Decision Process

D.1.2 Site Assessment

The CAI at CAU 477 involved soil sampling using rotosonic drilling techniques or hand tools. The investigation results identified arsenic, lead, and TPH-DRO in one sample each and radiological COCs that exceeded the PALs as defined in the CAIP (DTRA, 1999). The maximum concentration of the COCs identified at each site and their corresponding PALs (Tier 1 comparison) are presented in Tables D.1-1 (chemical results) and D.1-2 (radiological results). The radiological PALs are not the ones that were specified in the CAIP, see Section D.1.4.

Table D.1-1
Maximum Reported Chemical Values for Tier 1 Comparison
(Page 1 of 2)

Contaminant	CAS	Sample No	Result (mg/kg)	PAL (mg/kg)
1,2,4-Trimethylbenzene	95-63-6	NS-40-7	0.18	170
1,2-Dibromo-3-Chloropropane	96-12-8	NS-15-24	0.0021	2
1,2-Dichlorobenzene	95-50-1	NS-15-24	0.001	370
1,3,5-Trimethylbenzene	108-67-8	NS-40-7	0.059	70
2-Butanone	78-93-3	NS-50-10	0.025	110,000
2-Methylnaphthalene	91-57-6	NS-40-7	13	190
Acetone	67-64-1	NS-02-19	0.18	54,000
Arsenic	7440-38-2	NS-23-02	**38.8**	**23**
Barium	7440-39-3	NS-S1-01	5,300	67,000
Benzo(G,H,I)Perylene	191-24-2	NS-37-29	0.14	29,000
Bis(2-Ethylhexyl)Phthalate	117-81-7	NS-35-19	0.85	120
Cadmium	7440-43-9	NS-02-19	0.46	450
Carbon Tetrachloride	56-23-5	NS-40-19	0.002	0.55
Chlorobenzene	108-90-7	NS-17-40	0.00069	530
Chloroform	67-66-3	NS-40-19	0.0018	0.47
Chloromethane	74-87-3	NS-15-16	0.0051	160
Chromium	7440-47-3	NS-02-19	32	450
Diesel-Range Organics	68334-30-5	NS-40-7	**3,300**	**100**
Dimethyl Phthalate	131-11-3	NS-40-7	2.5	100,000
Ethylbenzene	100-41-4	NS-40-7	0.0064	400
Gasoline	8006-61-9	NS-40-7	0.68	100

Table D.1-1
Maximum Reported Chemical Values for Tier 1 Comparison
(Page 2 of 2)

Contaminant	CAS	Sample No	Result (mg/kg)	PAL (mg/kg)
Isopropylbenzene	98-82-8	NS-40-7	0.0072	2,000
Lead	7439-92-1	NS-23-02	**59,700**	**800**
M+P-Xylene	136777-61-2	NS-40-7	0.035	210
Mercury	7439-97-6	NS-46-85	0.8	310
Methylene Chloride	75-09-2	NS-40-7	0.011	21
Naphthalene	91-20-3	NS-40-7	7	190
N-Butylbenzene	104-51-8	NS-40-7	0.02	240
N-Propylbenzene	103-65-1	NS-40-7	0.015	240
O-Xylene	95-47-6	NS-40-7	0.025	210
P-Isopropyltoluene	99-87-6	NS-02-19	0.079	2,000
Pyrene	129-00-0	NS-40-7	4.3	29,000
Sec-Butylbenzene	135-98-8	NS-40-7	0.015	220
Selenium	7782-49-2	NS-S8-02	1.2	5,100
Silver	7440-22-4	NS-48-47	1.3	5,100
Styrene	100-42-5	NS-B-95	0.0011	1,700
Tert-Butylbenzene	98-06-6	NS-15-24	0.00083	390
Toluene	108-88-3	NS-40-7	0.0017	520
Trichloroethene	79-01-6	NS-40-19	0.0012	0.11

Table D.1-2
Maximum Reported Radiological Values for Tier 1 Comparison

Parameter	CAS	Sample_No	Result (pCi/g)	PAL[1] (pCi/g)
Bismuth-212	14913-49-6	NS-04-20	4.3	15
Bismuth-214	14733-03-0	NS-20-31	4.88	15
Cobalt-60	10198-40-0	NS-46-13.5	0.73	2.7
Cesium-137	10045-97-3	NS-46-13.5	**1,340**	**12.5**
Lead-212	15092-94-1	NS-23-05	**31.3**	**15**
Lead-214	15067-28-4	NS-23-05	6.9	15
Plutonium-239	15117-48-3	NS-46-13.5	0.55	12.7
Thallium-208	14913-50-9	NS-04-20	1.04	15

[1] PALs used as action levels. The PALs for radiological contaminants are based on background or the National Council of Radiation Protection and Measurement Report No. 129 recommended screening limits for construction, commercial, and industrial land use scenario (NCRP, 1999) scaled from 25- to 15-millirem-per-year dose and the generic guidelines for residual concentration of radionuclides in DOE Order 5400.5 (DOE, 1993).
[2] Bold indicates value exceeds the PAL.

D.1.3 Site Classification and Initial Response Action

The four major site classifications listed in Table 3 of the ASTM standard are: (1) immediate threat to human health, safety, and/or the environment; (2) short-term (0 to 2 years) threat to human health, safety, and/or the environment; (3) long-term (greater than 2 years) threat to human health, safety, and/or the environment; (4) no demonstrated long-term threats.

Based on the CAI, CAU 477 does not present an immediate threat to human health, safety, and/or the environment; therefore, no interim response actions are necessary at this site. The CAI demonstrated that the contamination present at CAU 477 is limited to the point of release, the N-Tunnel Muckpile. The results further showed that there has been no migration into the subsurface. Analytical results from the native material show no chemical or radiological contamination in the underlying native material. A discussion of the nature and extent of contamination is presented in Appendix A. Based on this information, CAS 12-06-03 (N-Tunnel Muckpile) is determined to be Classification 3 as defined by ASTM Method E 1739-95 (ASTM, 1999). At this site, COCs were identified that may pose long-term threats to human health or the environment.

D.1.4 Development of Tier 1 Look-Up Table of Risk-Based Screening Level Selection

Tier 1 action levels have been defined as the PALs established during the DQO process. The PALs are a tabulation of chemical-specific (but not site-specific) screening levels based on the type of media (soil) and potential exposure scenarios (industrial). These are very conservative estimates of risk, are preliminary in nature, and are used as action levels for site screening purposes. Although the PALs are not intended to be used as FALs, a FAL may be defined as the Tier 1 action level (i.e., PAL) if individual constituent analytical results are below the corresponding Tier 1 action level. The FAL may also be established as the Tier I action level if individual constituent analytical results exceed the corresponding Tier 1 action level value and implementation of a corrective action based on the final action level is practical. The PALs are defined as:

- The EPA Region 9 Risk-Based PRGs for Industrial Soils (2002).
- Background concentrations for RCRA metals will be evaluated when natural background exceeds the PAL, as is often the case with arsenic. Background is considered to be the mean plus two times the standard deviation of the mean based on data published in

Mineral and Energy Resource Assessment of the Nellis Air Force Range (NBMG, 1998; Moore, 1999).

- Concentrations for TPH-DRO above 100 mg/kg per NAC 445A.2272 (NAC, 2003b).

- For COPCs without established PRGs, a protocol similar to EPA Region 9 will be used to establish an action level; otherwise, an established PRG from another EPA region may be chosen.

- When the CAIP was written, the PALs for radionuclides were isotope-specific and defined as the higher of the maximum concentration for that isotope found in samples from undisturbed background locations in the vicinity of the NTS (McArthur and Miller, 1989; US Ecology and Atlan-Tech, 1991; Black and Townsend, 1996), from any of the three background samples collected during the investigation, or the POC as specified in the *Nevada Test Site Performance Objective for Certification of Nonradioactive Hazardous Waste* (BN, 1995).

  Since the corrective action was completed, the radiological PALs have been changed through agreement with NDEP as follows: The PALs for radioactive contaminants are based on the NCRP Report No. 129 recommended screening limits for construction, commercial, and industrial land-use scenarios (NCRP, 1999) scaled to 25-mrem/yr dose constraint (Appenzeller-Wing, 2004) and the generic guidelines for residual concentration of radionuclides in DOE Order 5400.5 (DOE, 1993).

The PALs were developed based on an industrial scenario. Because CAU 477 in Area 12 is not assigned any work stations and is considered to be in a remote or occasional use area, the use of industrial land use based PALs is conservative. The Tier 1 look-up table is defined as the PAL concentrations or activities defined in the CAIP.

D.1.5 Exposure Pathway Evaluation

The DQOs stated that site workers would only be exposed to COCs through oral ingestion, inhalation, or dermal contact (absorption) due to exposure to potentially contaminated media (i.e., soil) at the CASs. The results of the CAI showed that all COCs identified in CAU 477 are localized near the release points and have not significantly migrated laterally or vertically in the subsurface. Because the contaminants were only identified in the soil of the muckpile the only potential exposure pathway would be through worker contact with the contaminated soil. The lack of migration demonstrated by the analytical results, elapsed time since the suspected release, and the depth to groundwater supports the selection and evaluation of only the surface and shallow subsurface contact as the complete exposure pathway. Groundwater is not considered to be an exposure pathway.

D.1.6 Comparison of Site Conditions with Tier 1 Risk-Based Screening Levels

All analytical results for CAU 477 were less than corresponding Tier 1 action levels (i.e., PALs) except for those listed in Table D.1-3.

Table D.1-3
COPCs Detected Above Preliminary Action Levels

	TPH-DRO	Arsenic	Lead	Cesium-137	Lead-212
CAS 12-06-03 N-Tunnel Muckpile	X	X	X	X	X

D.1.7 Evaluation of Tier 1 Results

For all constituents at CAU 477 not listed in Section D.1.6, the FALs were established as the Tier 1 risk-based screening levels. It was determined that no further action is required for these constituents at CAU 477.

It was determined by DTRA that remediation of the remaining constituents listed in Table D.1-3 is not practical. Therefore, Tier 2 SSTLs were calculated for those constituents at each CAS.

D.1.8 Tier 1 Remedial Action Evaluation

TPH-DRO Evaluation

Remediation to Tier 1 action levels would be difficult and expensive while potentially not providing a significant risk reduction. Therefore, it was determined to assess the risk to human health posed by the hazardous constituents of TPH-DRO at CAU 477 under a Tier 2 evaluation before establishing FALs for TPH-DRO constituents or implementing a corrective action.

Chemical Evaluation

Actions to remediate arsenic and lead to Tier 1 action levels would be difficult and expensive while potentially not providing a significant risk reduction. The arsenic concentration that was above the PAL only occurred in one sample, and while being above the PAL, it was still not out side the range of naturally occurring arsenic in the state of Nevada. The lead sample that exceeded was also only in one sample, and a TCLP analysis was conducted on that sample proving that the lead was not mobile. Therefore, no further actions will be taken concerning these chemicals.

Radionuclide Evaluation

Even though Pb-212 and Pb-214 exceeded their PALs in one sample, they will not be moved to a Tier 2 analysis. These radionuclides are naturally occurring. Both of these exceedances occurred in a single sample of volcanic tuff bedrock from beneath the muckpile. No concentrations of these radionuclides exceeded the PALs in the samples collected above this sample, so these are most likely naturally occurring concentrations.

Actions to remediate Cs-137 to the Tier 1 action level would be difficult and expensive while potentially not providing a significant risk reduction. Therefore, these radionuclides were moved to a Tier 2 evaluation before establishing FALs or implementing a corrective action.

D.1.9 Tier 2 Evaluation

No additional data were needed to complete a Tier 2 evaluation.

D.1.10 Development of Tier 2 Table of SSTLs

Evaluation of TPH-DRO SSTLs

The ASTM Method E 1739-95 (ASTM, 1999) stipulates that risk evaluations for TPH-DRO contamination be calculated and evaluated based on the risk posed by the potentially hazardous constituents of TPH-DRO. Section 6.4.3, "Use of Total Petroleum Hydrocarbon Measurements" of ASTM Method E 1739-95 states: "TPH-d should not be used for risk assessment because the general measure of TPH-d provides insufficient information about the amounts of individual chemical(s) of concern present" (see also Sections X1.5.4 and X1.42 of Method E 1739-95). Therefore, the individual potentially hazardous constituents in TPH-DRO were compared to corresponding Tier 2 SSTLs to evaluate the need for corrective action at CAU 477. Although Tier 2 SSTLs are generally calculated using site-specific inputs and general risk formulas, the Tier 2 SSTLs selected for the hazardous constituents of TPH-DRO are the EPA Region 9 PRGs (EPA, 2002). These SSTLs and the maximum reported level for each diesel constituent per CAS are presented in Table D.1-4.

Table D.1-4
Tier 2 SSTLs and CAU 480 Results for
Hazardous Constituents of Diesel

CAS No.	Common Name	SSTL (mg/kg)	Maximum Reported Value (mg/kg)
108-67-8	1,3,5-Trimethylbenzene	70	0.011
91-57-6	2-Methylnaphthalene[a]	175,000	9.3
120-12-7	Anthracene	100,000	ND
71-43-2	Benzene	2.1	ND
56-55-3	Benzo(a)anthracene	1.4	ND
50-32-8	Benzo(a)pyrene	0.21	ND
205-99-2	Benzo(b)Fluoranthene	2.1	ND
191-24-2	Benzo(g,h,i)Perylene	29,000	ND
207-08-9	Benzo(k)Fluoranthene	21	ND
218-01-9	Chrysene	210	ND
100-41-4	Ethylbenzene	400	ND
206-44-0	Fluoranthene	22,000	ND
86-73-7	Fluorene	26,000	ND
91-20-3	Naphthalene	190	ND
104-51-8	N-Butylbenzene	240	0.02
103-65-1	N-Propylbenzene	240	0.015
85-01-8	Phenanthrene	100,000	ND
129-00-0	Pyrene	29,000	ND
108-88-3	Toluene	520	ND
1330-20-7	Total Xylene[b]	420	0.06

[a]Uses PRG for naphthalene as surrogate
[b]Total of m-, o-, and p-xylenes

CAS = Chemical Abstracts Service
mg/kg = Milligrams per kilograms
ND = Nondetect
SSTL = Site-specific target level

Evaluation of Chemical SSTLs

The only chemical that exceeded its PAL is lead. However, an SSTL cannot be calculated because the EPA considers it inappropriate to develop an inhalation chronic reference concentration (RfC) or an oral chronic reference dose (RfD) for inorganic lead because the health

effects of inorganic lead occur at concentrations so low as to be essentially without a threshold (EPA, 2006). For this reason, the PAL became the FAL. The SSTL, the maximum reported level, and the average level for lead are presented in Table D.1-5.

Table D.1-5
Tier 2 SSTLs and CAU 477 Results for Chemical Constituents

CAS	Common Name	12-06-03 (mg/kg)		
		SSTL	Maximum Result	Average
7439-92-1	Lead	800	59,700	1,825

Evaluation of Radiological Constituent SSTLs

The Tier 2 evaluation consisted of evaluating the mixture of all radionuclides detected at the CAS to develop Tier 2 action levels for the radionuclides that exceeded Tier 1 levels. The CAS specific Tier 2 action levels were calculated using the RESRAD code (version 6.22) and site-specific parameters. The RESRAD calculations were based on continued use of the site under the Occasional Use Area scenario, assuming that a site worker will be on site for 10 days per year, 8 hours a day for 5 years. A more detailed discussion of the RESRAD code, site-specific parameters used, and the printed RESRAD outputs are provided in Attachment A of this appendix. These SSTLs, the maximum reported level, and the average level for each radiological constituent are presented in Table D.1-6.

Table D.1-6
Tier 2 SSTLs and CAU 477 Results for Radiological Constituents

CAS	Common Name	12-06-03 (pCi/g)		
		SSTL	Maximum Result	Average
10045-97-3	Cesium-137	8.99E11	1340	36.44*

*This is an average of both random and biased samples

Although all detected radionuclides at the CAS were used in the sum-of-fractions calculation, and a unique Tier 2 action level was developed for all radionuclides, only the radionuclide that initially exceeded Tier 1 levels had a Tier 2 based FAL. The CAS specific FAL established for this radionuclide is the SSTL listed in Table D.1-6.

D.1.11 Comparison of Site Conditions with Tier 2 FALs

The Tier 2 action levels are typically compared to individual sample results from reasonable points of exposure (as opposed to the source areas as is done in Tier 1) on a point-by-point basis. Points of exposure are defined as those locations or areas at which an individual or population may come in contact with a COC originating from a CAS. For CAU 477, the Tier 2 action levels were compared to maximum constituent concentrations from each sample location and to the average concentration for the site.

A comparison of the maximum concentration of the hazardous constituents of TPH-DRO was conducted against the CAS-specific Tier 2 FALs as shown in Table D.1-4. All analytical results for potentially hazardous constituents in TPH-DRO were below the Occasional Use Area FALs for the N-Tunnel Muckpile (CAS 12-06-03).

A comparison of the maximum concentration of the hazardous chemicals identified above the Tier 1 action levels was conducted against the CAS-specific Tier 2 FALs as shown in Table D.1-5. The analytical result for lead exceeded the Occasional Use Area FALs for the N-Tunnel Muckpile (CAS 12-06-03).

A comparison between the maximum concentration of the radionuclides identified above Tier 1 action levels (Cs-137) was conducted against the CAS-specific Tier 2-based FALs listed in Table D.1-5. For the N-Tunnel Muckpile (CAS 12-06-03) the maximum concentration and average of Cs-137 is below the CAS-specific Occasional Use Area FAL.

D.1.12 Tier 2 Remedial Action Evaluation

Based on the Tier 2 evaluation of the TPH-DRO hazardous constituents, the chemical constituents, and the radiological constituents, CAU 477 is contaminated with inorganic lead but not contaminated with radiological or other chemical constituents. This CAS poses a risk so a remedial action needs to be implemented. Close in place with institutional controls is the most reasonable corrective action for CAU 477.

As all contaminant FALs were established as Tier 1 or Tier 2 action levels, a Tier 3 evaluation was considered unnecessary.

D.2.0 Regulatory Basis

The FFACO Part III, Section III.3 (FFACO, 1996) stipulates conformance with Chapter 445 of the NAC (NAC, 2003a). Section NAC 445A.227 lists the factors to be considered in determining whether a corrective action is required.

Section NAC 445A.227 states:

1. Except as otherwise provided in NAC 445A.22715, the Director may require an owner or operator to take corrective action if the release of a hazardous substance, hazardous waste, or a regulated substance contaminates soil and the level of contamination exceeds the action level established for the soil pursuant to NAC 445A.2272.
2. In determining whether corrective action is required, the Director shall consider:
   (a) The depth of any groundwater.
   (b) The distance to irrigation wells or wells for drinking water.
   (c) The type of soil that is contaminated.
   (d) The annual precipitation.
   (e) The type of waste or substance that was released.
   (f) The extent of the contamination.
   (g) The present and potential use for the land.
   (h) The preferred routes of migration.
   (i) The location of structures or impediments.
   (j) The potential for a hazard related to fire, vapor, or explosion.
   (k) Any other information specifically related to the site that the director determines is appropriate.

For a site where it is determined that corrective action is required (the corrective action process applies to all FFACO sites), Section NAC 445A.22705 (NAC, 2003c) stipulates a process to determine the necessary remediation standards (or FALs) based on an evaluation of the risk the site poses to public health and the environment.

Section NAC 445A.22705 states:

1. Except as otherwise provided in NAC 445A.22715, if an owner or operator is required to take corrective action pursuant to NAC 445A.227, the owner or operator may conduct an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary remediation standards or to establish that corrective action is not necessary. Such an evaluation must be conducted using Method E 1739-95, adopted by the ASTM, as it exists on October 3, 1996, or an equivalent method approved by the Division.

2. The Division shall determine whether an evaluation complies with the requirements of Method E 1739-95, or an equivalent method of testing approved by the Division. The Division may reject, require revisions be made to, or withdraw its concurrence with the evaluation at any time after the completion of the evaluation for the following reasons:

   (a) The evaluation does not comply with the applicable requirements for conducting the evaluation.

   (b) Conditions at the site have changed.

   (c) New information or previously unidentified information that would alter the results of the evaluation becomes available and demonstrates that the release may have a detrimental impact on public health or the environment.

Therefore, in compliance with Section NAC 445A.22705, DTRA conducted "an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary remediation standards or to establish that corrective action is not necessary" using ASTM Method E 1739-95.

D.3.0 Recommendations

Organic, inorganic, and radiological constituents detected in environmental samples during the CAI were evaluated against FALs to determine the nature and extent of COCs for CAU 477. Assessment of the data generated from the investigation activities indicates that the FAL was exceeded for inorganic lead in the muckpile. None of the other FALs for chemical and radiological constituents were exceeded.

As COCs were identified above corresponding FALs, it was determined that closure in place with use restrictions is the best option for closing CAU 477. This is based on the fact that even though the FALs were exceeded, this remote, controlled access site poses only limited risk overall to public heath and the environment. Given the limited number of COCs (lead only), the negligible lateral and vertical migration, and the lack of potential impact to groundwater, it would create a greater hazard to worker safety, public health, and the environment to remove the contamination, transport it, and bury it at another location.

No further corrective action is necessary.

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Attachment A

Derivation of Residual Radioactive Material Guidelines for Radionuclides in Soil at Corrective Action Unit (CAU) 477, Area 12 N-Tunnel Muckpile, Nevada Test Site, Nevada

Derivation of Residual Radioactive Material Guidelines for Radionuclides in Soil at Corrective Action Unit (CAU) 477, Area 12 N-Tunnel Muckpile, Nevada Test Site, Nevada

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Derivation of Residual Radioactive Material Guidelines for Radionuclides in Soil at Corrective Action Unit (CAU) 477, Area 12 N-Tunnel Muckpile, Nevada Test Site, Nevada

1.0 Introduction

The U.S. Department of Energy (DOE), the U.S. Department of Defense (DoD) (through the Defense Threat Reduction Agency [DTRA]), and the National Nuclear Security Administration Nevada Site Office (NNSA/NSO) Environmental Restoration Division have numerous sites impacted from the development, testing, and production of nuclear weapons. These impacts can take the form of chemical and/or radiological contaminants. Similar to its approach for chemical contamination, DoD and NNSA/NSO are committed to properly evaluating, radiologically characterizing, and where appropriate, remediating these sites to ensure the doses to radiation workers and members of the public are maintained as low as reasonably achievable (ALARA), at a minimum, below the primary dose limits as stated in DOE Order 5400.5 (DOE, 1993).

To accomplish this, the potential for residual radioactive contamination in soils must be evaluated to determine the status of compliance with the requirements of DOE Order 5400.5 (DOE, 1993). The DOE Order 5400.5 requires that: "The Authorized Limits shall be established to (1) provide that, at a minimum, the basic dose limits … will not be exceeded, or (2) be consistent with applicable generic guidelines." Because generic guidelines have not been established for volumetric residual radioactivity for the radionuclides of concern at CAU 477, Authorized Limits or final action levels (FALs) were derived using the Residual Radioactivity (RESRAD) model and computer code (Yu et al., 2001). The goal of this effort was to produce Authorized Limits, in units of picocuries per gram (pCi/g) in soil above background, for CAU 477 that would result in radiation doses less than 25 mrem per year (mrem/yr) to an industrial worker at the site.

To develop the FALs, a "realistic" yet conservative radiation dose analysis was conducted using approved exposure scenarios and site-specific data to determine the translation between surface soil concentrations and individual radiation doses. For this analysis, site-specific data included soil sampling results obtained during site investigation activities at CAU 477, and meteorological data obtained from the Air Resources Laboratory (ARL)/Special Operations and Research Division (SORD). This report provides the radiation dose modeling analysis supporting the technical derivation of the Authorized Limits for CAU 477, Area 12 N-Tunnel Muckpile, Nevada Test Site (NTS), Nevada. This report also defines the radionuclides considered and approved exposure scenarios for the NTS, identifies the applicable exposure pathways and key input data or assumptions, presents the radiation doses for unit concentrations of radionuclides in soil, and establishes the FALs for CAU 477.

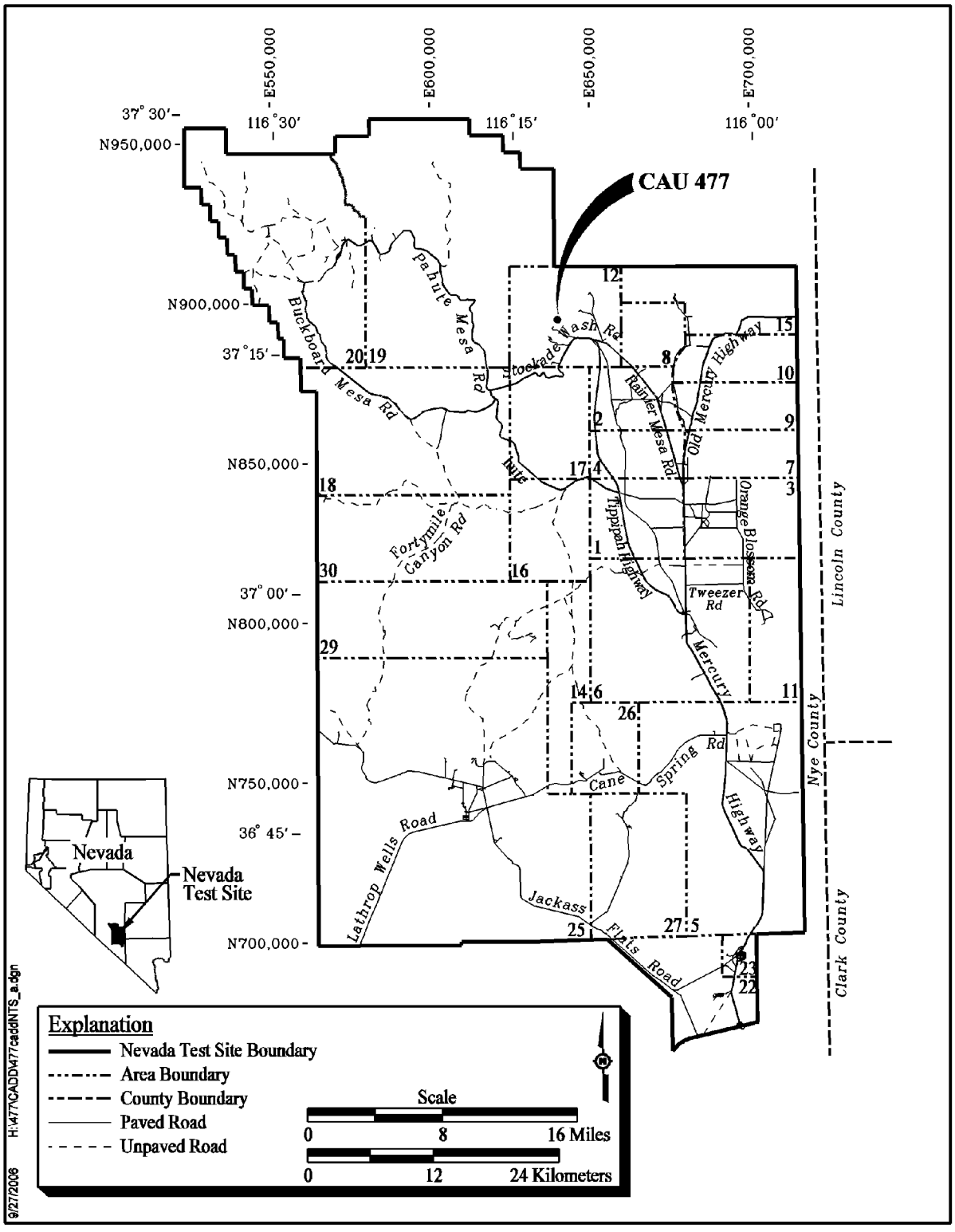

Figure 1-1. NTS Map Showing CAU 477 Location

2.0 Facility Description

The N-Tunnel Muckpile is located approximately 45 miles north of Mercury in Area 12 of the Nevada Test Site (Figure 1-1). The N-Tunnel, constructed beneath Rainier Mesa, was mined into the bedded ash flow tuff from 850 to 1,400 ft below the mesa surface. The tunnel was designed to withstand and contain pressures and temperatures created by the test events.

Corrective Action Unit 477 is comprised of only one CAS, Area 12 N-Tunnel Muckpile, which was operated between 1964 and 1993 during the period of nuclear and non-nuclear weapons effects testing in N-Tunnel. The muckpile is estimates to contain approximately 8,000,000 cubic feet of mining and re-entry debris. Less than one percent of this material is considered to be re-entry debris. Additional information relating to the site history, planning, and scope of the investigation is presented in the CAIP (DTRA, 1999).

2.1 Operational History

The operational history of the N-Tunnel Muckpile was determined from interpretation of aerial photographs and is described in existing documents and reports.

Records indicate that re-entry wastes may have been excavated and disposed of as a unit, however, segregation of mining, construction, and radioactive re-entry debris began 1974. In 1989, detailed segregation was expanded, and only waste rock and cementitious mixtures were permitted in the muckpile. In 1994, effluent discharge elimination plugs were emplaced in the tunnel as part of the N-Tunnel mothball program.

Aerial photograph evidences indicated that the muckpile began development around 1964 near the entrance to the N-Tunnel main and extension drifts. The first sequence of event-related materials was deposited during the second half of 1967 and continued as south- and southeast-trending fill successions until the last test event from which re-entry debris was generated in 1988. The muckpile appears to have a total depositional history of 29 years (1964-1993).

2.2 Release Information

Past surface activities of concern at CAU 477 include re-entry to the tunnel after some nuclear tests and involved additional horizontal mining. Such activities consequently generated re-entry debris consisting of rock waste and construction materials such as cementitious mixtures, wood, cabling, and scrap metal which could have contained low levels of radioactivity. Mining debris and some re-entry debris were stockpiled outside the tunnel entrance area, covering former drainage basins and washes. The materials generated during test events were hauled to the edge of the existing muckpile, dumped off the edge, and leveled. In the few cases where re-entry debris was radioactive, the debris was capped with approximately 10 ft of clean cover material. Release mechanisms, migration pathways, exposure pathways, and exposure points are described in the CAU 477 CAIP.

3.0 Site Investigation Activities

3.1 Site Investigation Plans

Corrective action investigation activities were performed as set forth in the CAU 477 CAIP (DTRA, 1999) from March 15 through April 27, 1999. The objectives of the CAU 477 CAIP were to address the decision statements in the project-specific Data Quality Objectives (DQOs) by:

- Characterizing the surface and near-surface (0-5 ft) muckpile material for impact from PCOCs.
- If present, determine the extent of contamination and evaluate with regard to potential future-use scenarios and utilization of muckpile as a capping material.
- Characterizing the muckpile subsurface (>5 ft) for impact from PCOCs and determine the extent of contamination.
- Characterizing the material in the buried retention ponds for impact from PCOCs and determine the extent of contamination.
- Characterizing the materials in the native soils (5 ft below the bottom of muckpile) for impact from PCOCs and determine the extent of contamination.
- Characterizing the native soils surrounding the muckpile to determine background levels of radioactivity and metals.
- Evaluate the PCOCs for potential leaching into the surrounding environment.

The DQO process is a seven-step strategic planning approach based upon the scientific method used to plan data collection activities for CAU 477, Area 12 N-Tunnel Muckpile, Nevada Test Site. The DQOs are designed to ensure that data collected will provide sufficient and reliable information to identify, evaluate and technically defend the recommended corrective actions (i.e., no further action, closure in place, or clean closure).

The primary objective of the investigation was to provide sufficient information and data to develop appropriate corrective action alternatives for each CAS in CAU 477. This objective was achieved by identifying the nature and extent, both horizontal and vertical of COCs (i.e., COPCs at concentrations above action levels).

The investigation strategy was developed by representatives of NDEP and DTRA, in accordance with U.S. Environmental Protection Agency (EPA) *Guidance for Quality Assurance Project Plans*, EPA QA/G-5 (EPA, 2002a) and *Guidance for the Data Quality Objectives Process*, EPA QA/G-4 (EPA, 2000b). The investigation strategy also identifies and references the associated EPA Quality System Documents entitled *Data Quality Objectives for Hazardous Waste Site Investigation*, EPA QA/G-4HW (EPA, 2000a), and *Guidance on Choosing a Sampling Design for Environmental Data Collection*, EPA QA/G-5S (EPA, 2002b), upon which the DQO process is based. The CAU 477 CAIP contains a detailed description of the investigation strategy and the DQO process.

3.2 Summary of Specific Site Investigation Activities

This section provides a brief description of work activities conducted to support the investigation of radioactive contamination at CAU 477.
From March 15 through April 27, 1999, CAI activities were performed at the N-Tunnel Muckpile as set forth in the CAIP (DTRA, 1999). The purpose of the CAI was to determine the presence and extent of potential contaminants of concern (PCOCs) within or beneath the muckpile, and to provide sufficient information and data to develop appropriate corrective action strategies for the muckpile. As outlined in the CAIP, the following tasks were performed:

- Three locations were identified and hand augured to a depth of 6 to 12 inches to collect background native soil samples. Samples were field screened and submitted for radionuclide and *Resource Conservation Recovery Act* (RCRA) metal analysis.
- Thirty-seven boreholes were drilled to characterize the subsurface of the muckpile (greater than 5 ft). This includes the muckpile contents, the buried retention pond sediments, and the native soil beneath the muckpile. A continuous core was extracted from each borehole from which a total of 75 samples was submitted for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), RCRA metals, total petroleum hydrocarbons (TPH), and radionuclide analysis.
- Thirteen boreholes were drilled to characterize the surface/shallow subsurface of the muckpile (less than 5 ft) and 13 samples were collected and submitted for VOCs, SVOCs, RCRA metals, TPH, and radionuclide analysis.

Field screening of the core recovered from the boreholes provide guidance for the sampling. Data collection locations are presented in Figure 2-1 of the CAU 477 CADD.

4.0 Site Investigation Sample Results

The RESRAD calculations are based on validated analytical soil sample results obtained during site investigation activities and other applicable information specified in the CAIP. The RESRAD calculations are based upon the value of the maximum radionuclide concentration. The RESRAD calculations of the area were performed for the contaminants of concern (COC) present in the CAU 477 muckpile using the maximum radionuclide concentrations obtained from the CAI soil sample results. Appendix A of the CAU 477 CADD contains a detailed description of the sample results, analytical parameters, and laboratory methods used to analyze the soil samples.

The maximum principal radionuclide concentrations (including background) detected at the CAU 477 included:

Table 4-1. CAU 477 Principal Radionuclide Concentration Found in Soil Samples

Sample Number	Sample Depth (ft bgs)	Radionuclide	pCi/g
NS-23-05	6	Am-241	690
NS-23-05	6	Ce-144	94
NS-23-05	6	Co-57	17
NS-23-05	6	U-235	70
NS-23-05	6	Eu-155	230
NS-46-13.5	13.5	Co-60	0.73
NS-46-13.5	13.5	Cs-134	0.53
NS-46-13.5	13.5	Cs-137	1340
NS-46-13.5	13.5	Pu-238	0.272
NS-46-13.5	13.5	Pu-239	0.55
NS-46-13.5	13.5	Ru-106	5.3
NS-46-13.5	13.5	Sb-125	2.7

Based on the operational history and analytical results, the radionuclide contaminants appear to be distributed in two layers inside the muckpile. As such, the RESRAD analysis will address this two-layer contamination accordingly.

5.0 Initial Concentrations for Principal Radionuclides

Principal radionuclides are defined as radionuclides with a half-life greater than six months. The decay products of any principal radionuclide down to, but not including, the next principal radionuclide in its decay chain are defined as associated radionuclides. RESRAD assumes that a principal radionuclide is in secular equilibrium with its associated radionuclides at the point of exposure. Therefore, associated radionuclides and radionuclides with half-lives less than six months are not input into the RESRAD calculations.

5.1 Authorized Values for Initial Concentrations of Principal Radionuclides

The authorized exposure scenarios specify that value of the arithmetic mean plus the 95 percent UCL obtained from site-specific sampling results be entered as the principal radionuclide concentrations for RESRAD calculates. The sample results for all samples with radionuclide concentrations above the MDC within the land parcels are entered into the EPA software application ProUCL version 3.0. The ProUCL software is used to calculate the 95 percent UCL for principal radionuclide concentrations based on the distribution of the unknown mean.

For instances where the ProUCL software determined that there was not enough data to calculate the 95 percent UCL for a specific radionuclide, the maximum concentration from the sample dataset was used as the initial concentration for that radionuclide.

5.2 Authorized Values Initial Concentrations of Principal Radionuclides for Area Averaging/Hot-Spot Scenarios

The DOE Order 5400.5 (DOE, 1993) states: "Residual concentrations of radioactive material in soil are defined as those in excess of background concentrations averaged over an area of 100 m^2" (5400.5, IV, 4.a.). DOE Order 5400.5 also states: "If the average concentration of any surface or below-surface area less than or equal to 25 m^2, exceeds the limit or guideline by a factor of $(100/A)^{0.5}$, [where A is the area (in square meters) of the region in which concentrations are elevated], limits for "hot-spots" shall also be developed and applied" (5400.5, IV, 4.a.(1)). DOE G 441.1-XX (DOE 2002) discusses the rationale for the hotspot criterion.

The purpose of the hot-spot criterion is to ensure that applying the homogeneous criteria, in which the concentrations of residual radioactive material are averaged over a 100 m^2 area, does not result in the release of small areas that, because of averaging, contain unacceptably high concentrations of residual radioactive material. The hot-spot criterion is used to supplement Authorized Limits for larger areas and is intended to prevent excessive exposures from a small, contaminated area that is within a larger area that meets the basic Authorized Limits. Thus, it is intended for use in areas where the residual radioactive material concentrations are not uniform. Also, the above hotspot criterion was derived conservatively, assuming the Authorized Limits were based on a dose constraint of 25 mrem/yr and selected to ensure unlikely exposure conditions would not cause the primary dose limit (100 mrem/yr) to be exceeded. The authorized exposure scenarios specify that the value of the maximum concentration of principal radionuclides obtained from site-specific sampling results be entered as the principal radionuclide concentrations for RESRAD hot-spot calculations. The authorized area parameters for RESRAD hot-spot calculations are 1 m^2, 10 m^2, and 100 m^2 contamination areas.

5.3 Inhomogeneous Contamination and Initial Radionuclide Concentrations

A contaminated zone is inhomogeneous if it contains a contaminated region within which the concentration of a radionuclide exceeds three times the average for the contaminated zone. RESRAD uses a mathematical construct that assumes uniform distribution of radionuclides within a volume. However, RESRAD recognizes that radiological contamination is inhomogeneous in nature and provides detailed guidance for applying inhomogeneous criteria (hot spot criteria, sum of fractions rule, etc.). The RESRAD User Manual states that the inhomogeneous release criteria are generally more realistic and hence less restrictive than the homogeneous release criteria. This shows that the approved initial radionuclide concentration values (i.e., arithmetic mean plus 95 percent UCL or the maximum radionuclide concentration from the sample dataset) will result in more restrictive release criteria. The arithmetic mean plus the 95 percent UCL are used for the initial concentrations of principal radionuclides when the sample results are obtained using a random sampling method. The maximum radionuclide concentration values are used for the initial concentrations of principal radionuclides when the sample results are obtained using a non-random (e.g., bias or judgmental sampling) sampling method.

RESRAD states that a statistical approach should always be considered as a first priority regarding the estimation of soil concentrations, as cited in the *Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil* (Yu et al., 1993). The 95 percent UCL represents a value that has a 5 percent chance that the actual mean of the dataset would exceed it. The 95 percent UCL is computed using the EPA code ProUCL. The code calculates the 95 percent UCL based on the distribution of the dataset (e.g., normal, log-normal, gamma, non-parametric, etc.).

The ProUCL software has been developed to compute an appropriate 95 percent UCL of the unknown population mean to support exposure assessment and cleanup decisions for EPA projects. A 95 percent UCL of the unknown population arithmetic mean is often used to:

- Estimate the EPC term,
- Determine the attainment of cleanup standards,
- Estimate background level mean contaminant concentrations, or
- Compare the soil concentrations with site-specific soil screening levels.

It is important to compute a reliable, conservative, and stable 95 percent UCL of the population mean using the available data. The 95 percent UCL should approximately provide the 95 percent coverage for the unknown population mean.

The EPA has recommended that the maximum value of the dataset be used for the initial EPC term when the 95 percent UCL exceeds the maximum (EPA RAGS Document, 1992). However, if the maximum value of the dataset is used, then most of the statistical data associated with the distribution of the dataset is ignored (except for the maximum). Therefore, by using the mean plus the 95 percent UCL the statistical data associated with the dataset is retained and the value approaches or exceeds the maximum value of the dataset as recommended by EPA.

5.4 Initial Concentrations of Principal Radionuclide for CAU 477

The initial radionuclide concentrations used for the RESRAD calculations are those listed in Table 4-1. These maximum radionuclide concentration values were used to perform the RESRAD calculations to demonstrate conservatism.

6.0 Authorized RESRAD Exposure Pathways and Scenarios

This section describes the input parameters, exposures scenarios, and guidance for calculating site-specific radiological remediation levels for projects using the RESRAD computer code, as agreed to by NNSA/NSO, Stoller-Navarro Joint Venture (SNJV), the NTS M&O Contractor (M&O), and NDEP.

6.1 Guidance for RESRAD Calculations

The guidance in this section was developed by NNSA/NSO, SNJV, M&O, and NDEP and is only applicable to soils containing residual radioactive material. This guidance does not apply to structures, facilities, equipment, and building materials containing contaminated surfaces or volume contamination. The primary dose limit for any member of the public is 100-mrem total effective dose equivalent (TEDE) in a year. This limit applies to the sum of internal and external doses resulting from all modes of exposure to all radiation sources other than background radiation and doses received as a patient from medical sources as required by DOE 5400.5, II.1.a.(3)(a) (DOE, 1993). The dose constraint is defined as one quarter of the dose limit (i.e., 25-mrem) and will be applied to ensure that in a 1,000-year period the maximally exposed individual does not exceed the dose constraint in any single year. The requirements of Chapter IV of DOE 5400.5 Chapter IV will not specifically apply if NNSA/NSO chooses to continue to own and actively control access or use of the site. However, the radiation protection requirements in the other sections of DOE 5400.5 will apply to NNSA/NSO owned and maintained sites.

Due to the large spatial variability in background amongst sites, the "above background criterion" will be defined as the concentration of a specific radionuclide in soil that equals or exceeds its corresponding PAL. The source data for these radionuclide specific PALs are taken directly from NCRP Report No. 129 Table 2.1, Construction, Commercial, Industrial land-use scenario column for a 25-mrem dose constraint (NCRP, 1999). The generic guidelines for residual concentrations of Radium (Ra)-226, Ra-228, Thorium (Th)-230, and Th-232 are found in Chapter IV of DOE Order 5400.5, Change 2 "*Radiation Protection of the Public and Environment*."

Background radiation refers to the local area and includes:

- Concentration of naturally occurring radionuclides.
- Cosmic radiation.
- Radionuclides of anthropogenic origin that have been globally dispersed and are present at low concentrations such as fallout from nuclear weapons. (Note: This is not the case at the NTS because the historical aspects of the NTS, e.g., above- and below-ground testing, and other operations resulted in dispersion of radionuclides locally.)

Due to the impracticality of determining "true" background, a dose constraint with no background subtraction will be used (i.e., a dose constraint not in excess of background). The use of the dose constraint with no background subtraction is a far more conservative and sensitive approach because it does not deal with the uncertainty of natural background.

6.2 Description of Approved Scenarios

Based on the future land use as identified in the *Nevada Test Site Resource Management Plan* (DOE/NV, 1998), the following two exposure scenarios have been identified as "actual" and "likely" use scenarios. Stoller-Navarro Joint Venture has approval to use two scenarios (Scenario A and Scenario B) for use with the RESRAD code (NDEP, 2004). Both scenarios consider radiation exposures to the critical population group via the following pathways:

- Direct exposure to external radiation from the contaminated soil
- Internal dose from inhalation of airborne radionuclides
- Internal dose from ingestion of contaminated soil

The two scenarios vary the parameters associated with the future land use of the site but use the same dose constraint parameter of 25 mrem/yr. Scenario A is approved for sites in Mercury or within 500 ft of an active building. Scenario B is approved for all other sites. Scenarios A and B are briefly described below.

For Scenario A, the future land use assumes continued industrial use of the site. This scenario addresses long-term exposure received by industrial workers exposed daily to residual levels of radionuclides in soil during an average workday outdoors on site (EPA, 1991). Scenario A parameters are based on the following:

- A worker will be outdoors at the site for a total of 2,000 hr per year (hr/yr) (250 days per year, 8 hours per day) for a duration of 25 years.
- Indoor fraction time is zero, which means that the worker is outside being exposed for the entire workday.
- The outdoor time fraction is 0.228 and is calculated by dividing the total work hours at the site per year (2,000 hr/yr) by the total number of hours in a year (8,760 hr/yr).
- Worker exposures are limited to working hours and do not include contributions from ingestion of drinking water, plant foods, meat, or fish taken from the immediate area.

For Scenario B, the future land use assumes land use restrictions with a low occupancy factor and lighter work activities at the site. The assumptions for Scenario B include the following:

- A worker will be at the site and outdoors for a total of 335 hr/yr for a duration of 25 years.
- The indoor fraction time is zero.
- The outdoor time fraction is 0.038, which is calculated by dividing the total work hours at the site per year (335 hr/yr) by the total number of hours in a year (8,760 hr/yr).
- The worker exposures are limited to working hours and do not include contributions from ingestion of drinking water, plant foods, meat or fish taken from the immediate area.

When Scenario B is selected, a Use Restriction will be included at closure that will state the use scenario and the requirement for an occupant agency or entity to re-evaluate the closure if site use changes to fit the parameters of Scenario A.

Table 6-1 lists the pathways considered for Scenarios A and B.

Table 6-1. Summary of Pathways Considered for Scenarios A and B

Pathway	Scenario A	Scenario B
External exposure	Yes	Yes
Particulate inhalation	Yes	Yes
Radon inhalation	No	No
Ingestion of soil	Yes	Yes
Ingestion of produce from on-site garden	No	No
Ingestion of meat from on-site livestock	No	No
Ingestion of milk from on-site livestock	No	No
Ingestion of fish from on-site pond	No	No
Ingestion of water from on-site well	No	No

6.3 RESRAD Parameters

The RESRAD User's Manual states that: "The RESRAD default parameter values were carefully selected and are realistic, although conservative, parameter values. (In most cases, use of these values will not result in underestimation of the dose or risk.) Site-specific parameters should be used whenever possible. Therefore, use of default values that significantly overestimate the dose or risk for a particular site is discouraged" (Yu et al., 2001).

Table 6-2 lists all of the RESRAD default values along with the site-specific RESRAD parameters approved for use with Scenarios A and B. A reference or reason is provided for parameters that require site-specific input.

Table 6-2. Approved RESRAD Parameters

(Page 1 of 6)

Parameter	Units	Scenario A	Scenario B	Defaults	Reference/Rationale
Dose Conversion Factors					Use FGR 13 Morbidity
R02 Exposure Pathways					
Pathway 1- External Gamma	Active		Active		
Pathway 2- Inhalation		Active	Active		
Pathway 3- Plant Ingestion		Suppressed	Suppressed		
Pathway 4- Meat Ingestion		Suppressed	Suppressed		
Pathway 5- Milk Ingestion		Suppressed	Suppressed		
Pathway 6- Aquatic Foods		Suppressed	Suppressed		
Pathway 7- Drinking Water		Suppressed	Suppressed		
Pathway 8- Soil Ingestion		Active	Active		
Pathway 9- Radon		Suppressed	Suppressed		
R011 Contaminated Zone					
Area of CZ	m^2	Site Specific	Site Specific	1.000E+04	Maximum area of contamination out to two successive sample intervals below PALs. (~ 15 ft intervals laterally)
Thickness of CZ	m	Site Specific	Site Specific	2.000E+00	Maximum identified depth plus two successive intervals below PALs as identified during the site characterization. (~ 5 ft. intervals vertically)
Length Parallel to Aquifer Flow	m	not used	not used	1.000E+02	Not used with the above pathway selection
Radiation Dose Limit	mrem/yr	25	25	2.5E+001	RESRAD Default (DOE, 1993)
Elapsed Time Since Placement of Material	yr	0.0	0.0	0.0	RESRAD Default
R012 Initial Principal Radionuclide					
Site Specific Parent Radionuclide with half-life greater than 180 days, does not include naturally occurring and primordial radionuclides	pCi/g	Site Specific	Site Specific	0.0	The arithmetic mean plus the 95% UCL for the site.

Table 6-2. Approved RESRAD Parameters

(Page 2 of 6)

Parameter	Units	Scenario A	Scenario B	Defaults	Reference/Rationale
R013 Cover and Contaminated Zone Hydrological Data					
Cover Depth	m	Site Specific	Site Specific	0.0	The minimum depth as identified during the site characterization
Density of Cover Material	g/cm^3	1.5	1.5	1.5	RESRAD Default unless site data significantly different
Cover Depth Erosion Rate	m/yr	1.000E-03	1.000E-03	1.000E-03	RESRAD Default unless site data significantly different
Density of Contaminated Zone	g/cm^3	1.5	1.5	1.5	RESRAD Default unless site data significantly different
Contamination Zone Erosion Rate	m/yr	1.000E-03	1.000E-03	1.000E-03	RESRAD Default unless site data significantly different
Contaminated Zone Total Porosity	-	4.000E-01	4.000E-01	4.000E-01	RESRAD Default unless site data significantly different
Contaminated Zone Field Capacity	-	2.000E-01	2.000E-01	2.000E-01	RESRAD Default unless site data significantly different
Contaminated Zone Hydraulic Conductivity	m/yr	1.000E+01	1.000E+01	1.000E+01	RESRAD Default unless site data significantly different
Contaminated Zone b Parameter	-	5.300E+00	5.300E+00	5.300E+00	RESRAD Default unless site data significantly different
Average Annual Wind Speed	m/sec	Site Specific	Site Specific	2.000E+00	Data from Air Resources Laboratory http://www.sord.nv.doe.gov/arlsord-1.htm
Humidity in Air	g/m^3	not used	not used	8.000E+00	Not used with the above pathway selection
Evapotranspiration Coefficient	-	5.000E-01	5.000E-01	5.000E-01	RESRAD Default not significant due to lack of groundwater pathway
Precipitation	m/yr	Site Specific	Site Specific	1.000E+00	Data from Air Resources Laboratory http://www.sord.nv.doe.gov/arlsord-1.htm
Irrigation	m/yr	0	0	2.000E-01	Assumes no artificial supply of water to soil
Irrigation Mode	-	overhead	overhead	overhead	RESRAD Default
Runoff Coefficient	-	4.000E-01	4.000E-01	2.000E-01	Open Sandy Loam 30% impervious Table 10.1 (Yu, et. al., 1993)
Watershed Area for Nearby Stream or Pond	m^2	not used	not used	1.000E+06	Not used with the above pathway selection
Accuracy for Water/Soil Computations	-	not used	not used	1.000E-03	Not used with the above pathway selection

Table 6-2. Approved RESRAD Parameters

(Page 3 of 6)

Parameter	Units	Scenario A	Scenario B	Defaults	Reference/Rationale
R014 Saturated Zone Hydrological Data					
Density of Saturated Zone	g/cm^3	not used	not used	1.500E+00	Not used with the above pathway selection
Saturated Zone Total Porosity	-	not used	not used	4.000E-01	Not used with the above pathway selection
Saturated Zone Effective Porosity	-	not used	not used	2.000E-01	Not used with the above pathway selection
Saturated Zone Field Capacity	-	not used	not used	2.000E-01	Not used with the above pathway selection
Saturated Zone Hydraulic Conductivity	m/yr	not used	not used	1.000E+02	Not used with the above pathway selection
Saturated Zone Hydraulic Gradient	-	not used	not used	2.000E-02	Not used with the above pathway selection
Saturated Zone b Parameter	-	not used	not used	5.300E+00	Not used with the above pathway selection
Water Table Drop Rate	m/yr	not used	not used	1.000E-03	Not used with the above pathway selection
Well Pump Intake Depth	m	not used	not used	1.000E+01	Not used with the above pathway selection
Model: Nondispersion or Mass-Balance	-	ND	ND	ND	RESRAD Default
Well Pumping Rate	m^3/yr	not used	not used	2.500E+02	Not used with the above pathway selection
R015 Uncontaminated and Unsaturated Strata Hydrological Data					
Number of Unsaturated Zone Strata	-	not used	not used	1	Not used with the above pathway selection
Thickness	m	not used	not used	4.000E+00	Not used with the above pathway selection
Soil Density	g/cm^3	not used	not used	1.500E+00	Not used with the above pathway selection
Total Porosity	-	not used	not used	4.000E-01	Not used with the above pathway selection
Effective Porosity	-	not used	not used	2.000E-01	Not used with the above pathway selection
Field Capacity	-	not used	not used	2.000E-01	Not used with the above pathway selection
Soil-specific b Parameter	-	not used	not used	5.300E+00	Not used with the above pathway selection
Hydraulic Conductivity	m/yr	not used	not used	1.000E+01	Not used with the above pathway selection

Table 6-2. Approved RESRAD Parameters
(Page 4 of 6)

Parameter	Units	Scenario A	Scenario B	Defaults	Reference/Rationale
R016 Distribution Coefficients and Leach Rates					
Contaminated Zone K_d (all Zones)	cm^3/g				RESRAD Defaults
Saturated Leach Rate	/yr	0.0	0.0	0.0	Not used
Solubility Constant	-	0.0	0.0	0.0	Not used
R017 Inhalation and External Gamma					
Inhalation Rate	m^3/yr	8.400E+03	1.230E+04	8.400E+03	RESRAD Default and for an individual performing outdoor activities, a typical activity mix can consist of 37% at a moderate activity level, 28% at both resting and light activity levels, and 7% at a heavy activity level, which results in a 1.4 m^3/h (12,300 m^3/yr) inhalation rate. (Yu, et. al., 1993)
Mass Loading for Inhalation	g/m^3	6.00E-04	6.00E-04	1E-04	The estimated mass loading for construction activities. (Yu, et. al., 1993)
Exposure Duration	yr	25	25	30	Standard for Industrial/Commercial Scenario
Shielding Factor Inhalation	-	1	1	0.4	Assumes no indoor time fraction.
Shielding Factor External Gamma	-	1	1	0.7	Assumes no indoor time fraction.
Fraction of Time Spent Indoors	-	0.0	0.0	0.5	Assumes no indoor time fraction.
Fraction of Time Spent Outdoors	-	0.228	0.038	0.25	Based on Industrial/Commercial use scenarios for standard occupancy and low occupancy.
Shape Factor	-	1.0	1.0	1.0	RESRAD Default

Table 6-2. Approved RESRAD Parameters

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Parameter	Units	Scenario A	Scenario B	Defaults	Reference/Rationale
R018 Ingestion Pathway Data, Dietary Parameters					
Fruits, Vegetables, and Grain Consumption	kg/yr	not used	not used	1.600E+02	Not used with the above pathway selection
Leafy Vegetable Consumption	kg/yr	not used	not used	1.400E+01	Not used with the above pathway selection
Milk Consumption	L/yr	not used	not used	9.200E+01	Not used with the above pathway selection
Meat and Poultry Consumption	kg/yr	not used	not used	6.300E+01	Not used with the above pathway selection
Fish Consumption	kg/yr	not used	not used	5.400E+00	Not used with the above pathway selection
Other Seafood Consumption	kg/yr	not used	not used	9.000E-01	Not used with the above pathway selection
Soil Ingestion Rate	g/yr	1.752E+02	1.752E+02	36.5	480 mg/day (EPA, 1991)
Drinking Water Intake	L/yr	not used	not used	5.100E+02	Not used with the above pathway selection
Drinking Water Contaminated Fraction	-	not used	not used	1.000E+00	Not used with the above pathway selection
Household Water Contaminated Fraction	-	not used	not used	1.000E+00	Not used with the above pathway selection
Livestock Water Contaminated Fraction	-	not used	not used	1.000E+00	Not used with the above pathway selection
Irrigation Water Contaminated Fraction	-	not used	not used	1.000E+00	Not used with the above pathway selection
Aquatic Food Contamination Fraction	-	not used	not used	5.000E-01	Not used with the above pathway selection
Plant Food Contamination Fraction	-	not used	not used	-1	Not used with the above pathway selection
Meat Contamination Fraction	-	not used	not used	-1	Not used with the above pathway selection
Milk Contamination Fraction	-	not used	not used	-1	Not used with the above pathway selection
R019 Ingestion Pathway Data, Nondietary					
Livestock Fodder Intake for Meat	kg/day	not used	not used	6.800E+01	Not used with the above pathway selection
Livestock Fodder Intake for Milk	kg/day	not used	not used	5.500E+01	Not used with the above pathway selection
Livestock Water Intake for Meat	L/day	not used	not used	5.000E+01	Not used with the above pathway selection
Livestock Water Intake for Milk	L/day	not used	not used	1.600E+02	Not used with the above pathway selection

Table 6-2. Approved RESRAD Parameters
(Page 6 of 6)

Parameter	Units	Scenario A	Scenario B	Defaults	Reference/Rationale
Livestock Soil Intake	kg/day	not used	not used	5.000E-01	Not used with the above pathway selection
Mass Loading for Foliar Deposition	g/m^3	not used	not used	1.000E-04	Not used with the above pathway selection
Depth of Soil Mixing layer	m	not used	not used	1.500E-01	Not used with the above pathway selection
Depth of Roots	m	not used	not used	9.000E-01	Not used with the above pathway selection
Drinking Water Fraction from Groundwater	-	not used	not used	1.000E+00	Not used with the above pathway selection
Household Water Fraction from Groundwater	-	not used	not used	1.000E+00	Not used with the above pathway selection
Livestock Water Fraction from Groundwater	-	not used	not used	1.000E+00	Not used with the above pathway selection
Irrigation Fraction from Groundwater	-	not used	not used	1.000E+00	Not used with the above pathway selection
R021 Radon					
Radon Parameters Not Used					Not used with the above pathway selection

6.4 Residual Radioactive Material Guidelines

The residual radioactive material guideline represents the concentration of residual radioactive material that can remain in place and still allow use of that area without radiological restrictions. Using site-specific parameters and sample analysis results, the radioactive material guideline, G, can be calculated for a given dose limit of H_{EL} for an individual as follows:

$$G = H_{EL} / DSR ,$$

where DSR is the total dose/source concentration ratio. The dose limit H_{EL}, used to derive the residual radioactive material guideline is 25 mrem/yr.

Single radionuclide guidelines are calculated for individual radionuclides such that the annual dose to industrial/construction workers at the site should not exceed an annual dose limitation of 25 mrem/yr. Sites contaminated with two or more radionuclides (i.e., a mixture of radionuclides) require further evaluation to ensure that collective exposures from individual radionuclides do not exceed the 25 mrem/yr annual dose constraint. This evaluation is performed using a sum of the fractions method. The initial soil concentration of each radionuclide is divided by the single radionuclide guideline for that radionuclide to produce a ratio. These ratios are then summed. If the sum is less than or equal to unity, then the collective annual dose from all radionuclides at the site should not exceed the 25 mrem/yr annual dose constraint. If the sum does exceed unity, the annual dose to industrial/construction workers could exceed the 25 mrem/yr dose constraint, even if the concentrations of residual radionuclides at the site are below the single radionuclide guideline values. For sites where the sum of the ratios exceeds unity, residual radioactive material guidelines for mixtures of radionuclides are calculated such that the following equation is satisfied:

$$\overline{M} = \sum_i \overline{S}_i(0) / G_i(t_m) \leq 1$$

Where:
- $\overline{M}$ = average mixture sum (dimensionless)
- $\overline{S}_i(0)$ = initial concentration of the *i*th principal radionuclide averaged over an area determined by scenario activities
- $G_i(t_m)$ = single radionuclide soil concentration guideline for the *i*th principal radionuclide at time t maximum.

For a site where the sum of the ratios does not exceed unity, the residual radioactive guidelines for single radionuclides are the radionuclide concentrations to be used as the FAL. For sites where the sum of the ratios exceeds unity, the residual radioactive guidelines for mixtures of radionuclides are mathematically adjusted so that the above equation is satisfied. Those adjusted values are then used as the FAL.

7.0 RESRAD Calculations for CAU 477, Area 12 N-Tunnel Muckpile

This section discuses the RESRAD calculations and results for CAU 477.

7.1 Selection of RESRAD Exposure Scenario

Scenario B was selected as the exposure scenario for the CAU 477 because of the remote location of the site. Because Scenario B parameters will be used for these calculations, a Use Restriction will be implemented at closure that will state the use scenario and the requirement for an occupant agency or entity to re-evaluate the closure if site use changes to fit the parameters of Scenario A.

7.2 User Input Parameters

The RESRAD default parameters that were modified for the calculations performed for CAU 477 in this report and the site-specific values entered are presented in Table 7-1, RESRAD Parameter Input Values for CAU 477. A complete list of the RESRAD default parameters and the parameters used for CAU 477 is provided in Table A.1 of Exhibit A. The initial radionuclide concentrations used for analyses are those listed in Table 4-1.

7.3 Radionuclide Concentrations and Dose Estimates

The maximum dose results from RESRAD calculations for the CAU 477 is 5.921E-02 mrem/yr occurring at approximately year 200 for the layer 6 ft data, and 4.282E-22 mrem/yr at year zero for layer 13.5 ft data. The more conservative result (5.921E-02 mrem/yr) is used for discussion in this section. The detailed RESRAD results for all three portions of this CAS are provided in Exhibit B, RESRAD Summary Report: CAU 477.

Uncertainty in the derivation of dose estimates and dose/source contribution ratios comes from the distribution of possible input parameter values, as well as uncertainty in the conceptual model used to represent the site. The pathway contributing to the total annual dose at the time of maximum dose occurs (approximately year 200) are almost all (91.25 percent) for external exposure, 7.39 percent for inhalation, and 1.36 percent for soil ingestion pathways. Therefore, uncertainties in the following parameters: Erosion rates, thickness of contaminated zone, occupancy factors, and wind speed have the greatest significance on the model predictions.

The maximum dose contributions and total dose/source concentration ratios for the muckpile under Scenario B parameters have been predicted to occur at time year 200. The calculated maximum dose contributions for all considered pathways are presented in Table 7-2, Maximum Dose Contributions for Using Scenario B. Figure 7-1, CAU 477 Scenario B: Dose Rate Per Year All Radionuclides Summed, All Pathways Summed, shows that at any time over the 1,000 years, the TEDE to industrial/construction workers for the considered pathways is below the 25 mrem/yr dose constraint.

Figure 7-2, CAU 477 Scenario B: Annual Dose All Radionuclides Summed, Component Pathways, shows the breakdown of the total dose into the component pathways. Together, Table 7-2 and Figures 7-1 and 7-2 show that the dose from U-235, the major contributing radionuclide, at year 200 is 5.379E-02 mrem/yr and doses from all radionuclides drop to zero after the 1,000-year time interval.

Because the radionuclide concentrations found at this site do not pose a dose level above the 25 mrem/yr constraint at any time under the current site conditions, no remediation action is necessary for the site. However, controls that minimize the spread of radioactive contamination into uncontaminated areas and reduced erosion rate are recommended for this site. Nonetheless, the site should be posted as underground radioactive materials.

7.4 Residual Radioactive Material Guidelines for CAU 477

The sum of the ratios for CAU 477 do not exceeded unity with either 6 ft or 13.5 ft data. Table 7-3 presents the calculations results for deriving guidelines for radionuclides for this CAU. The residual radioactive material guidelines for single radionuclides and mixture radionuclides are listed in Table 7-4, Residual Radioactive Material Guidelines for Single Radionuclides and Radionuclide Mixtures. The FALs for the CAU 477 scenario are the residual radioactive material guideline values for single radionuclides.

Table 7-1. RESRAD Parameters Input Values for CAU 477

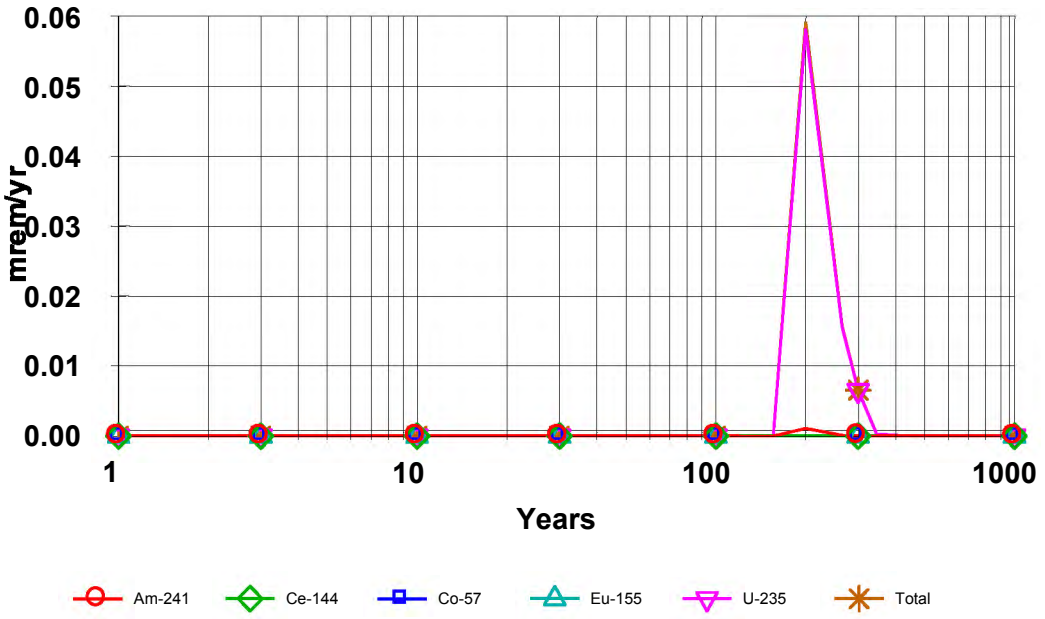
(Page 1 of 2)

Parameter	Units	CAU 477	Defaults	Reference/Rationale
Area of CZ	m^2	1.000E+02	1.000E+04	Estimated using the site boundary
Thickness of CZ	m	1.500E-01	2.000E+00	Top layer of the contamination soil
Principal radionuclides	pCi/g	See Table 7.2	0.0	Initial concentrations are the maximum concentrations from sample results: maximum for biased sample or average for random sample.
Average Annual Wind Speed	m/sec	3.4	2.000E+00	Data from Air Resource Laboratory (2005)
Precipitation	m/yr	3.260E-01	1.000E+00	Data from Air Resources Laboratory
Runoff Coefficient	-	4.000E-01	2.000E-01	Open Sandy Loam 30% impervious Table 10.1 (Yu, et al., 1993)
Inhalation Rate	m^3/yr	1.230E+04	8.400E+03	RESRAD Default and for an individual performing outdoor activities, a typical activity mix can consist of 37% at a moderate activity level, 28% at both resting and light activity levels, and 7% at a heavy activity level, which results in a 1.4 m^3/h (12,300 m^3/yr) inhalation rate. (Yu, et al., 1993)
Mass Loading for Inhalation	g/m^3	6.00E-04	1E-04	The estimated mass loading for construction activities. (Yu, et al., 1993)
Exposure Duration	yr	25	30	Standard for Industrial/Commercial Scenario
Shielding Factor Inhalation	-	1.0	0.4	Assumes no indoor time fraction
Shielding Factor External Gamma	-	1.0	0.7	Assumes no indoor time fraction
Fraction of Time Spent Indoors	-	0.0	0.5	Assumes no indoor time fraction
Fraction of Time Spent Outdoors	-	0.038	0.25	Scenario specific based on Industrial/ Commercial Use Scenarios for standard occupancy and low occupancy.
Soil Ingestion Rate	g/yr	1.752E+02	36.5	EPA, 1991; 480 mg/day

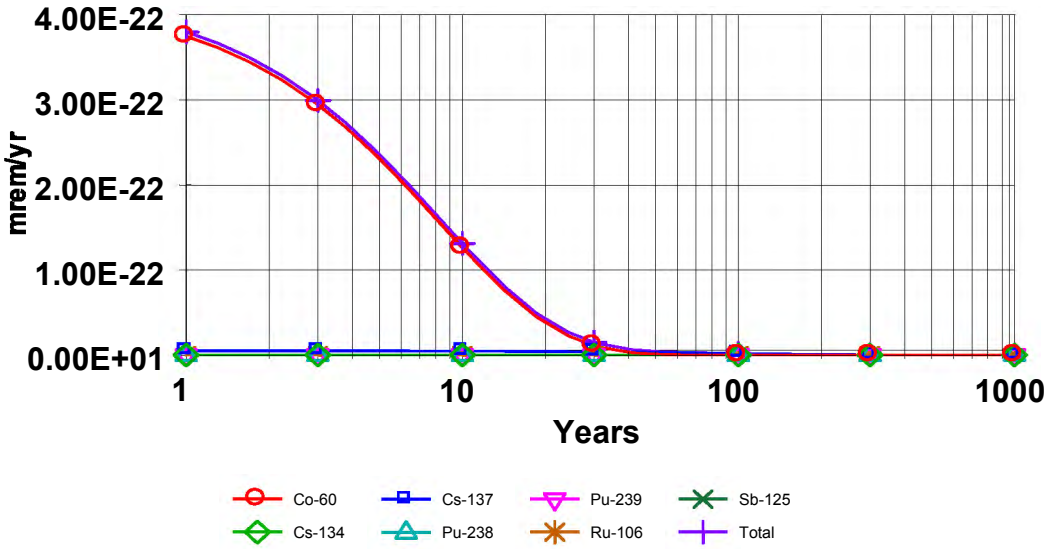
Table 7-1. RESRAD Parameters Input Values for CAU 477

(Page 2 of 2)

cm^3/g = Cubic centimeters per gram
g/cm^3 = Grams per cubic centimeter
g/m^3 = Grams per cubic meter
g/yr = Grams per year
kg/day = Kilograms per day
kg/yr = Kilograms per year
L/day = Liters per day
L/yr = Liters per year
m = Meter
m^2 = Square meter
m^2 = Square meter
m/sec = Meters per second
m/yr = Meters per year
m^3/h = Cubic meters per hour
m^3/yr = Cubic meters per year
mrem/yr = Millirem per year
N/A = Not applicable
pCi/g = Picocuries per gram
yr = Year
/yr = Per year
UCL = Upper confidence level

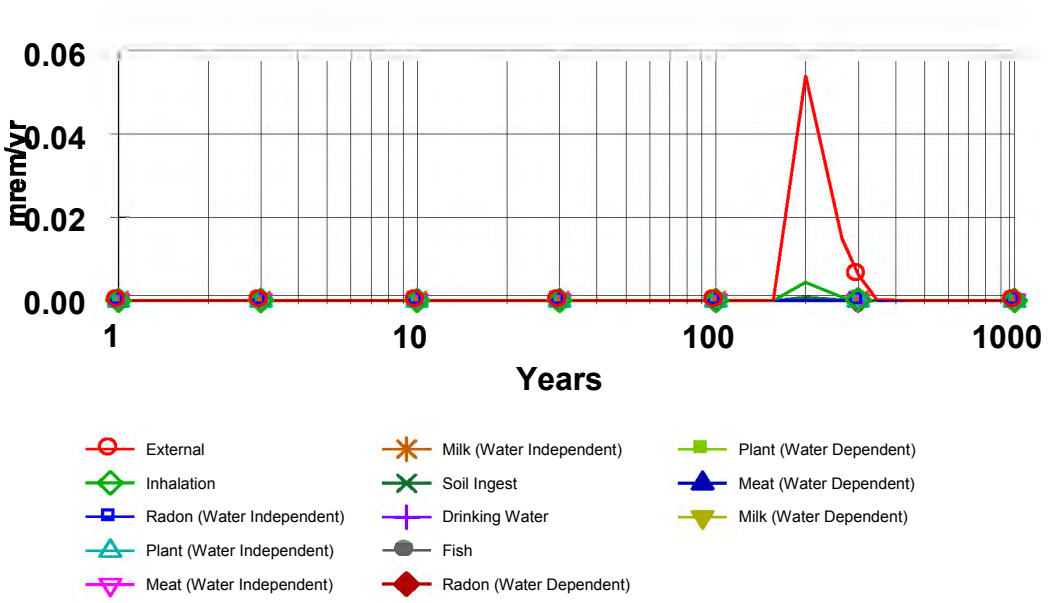


N Tunnel Muckpile Dose by All Radionuclides Summed and All Pathways Summed (6ft Data)

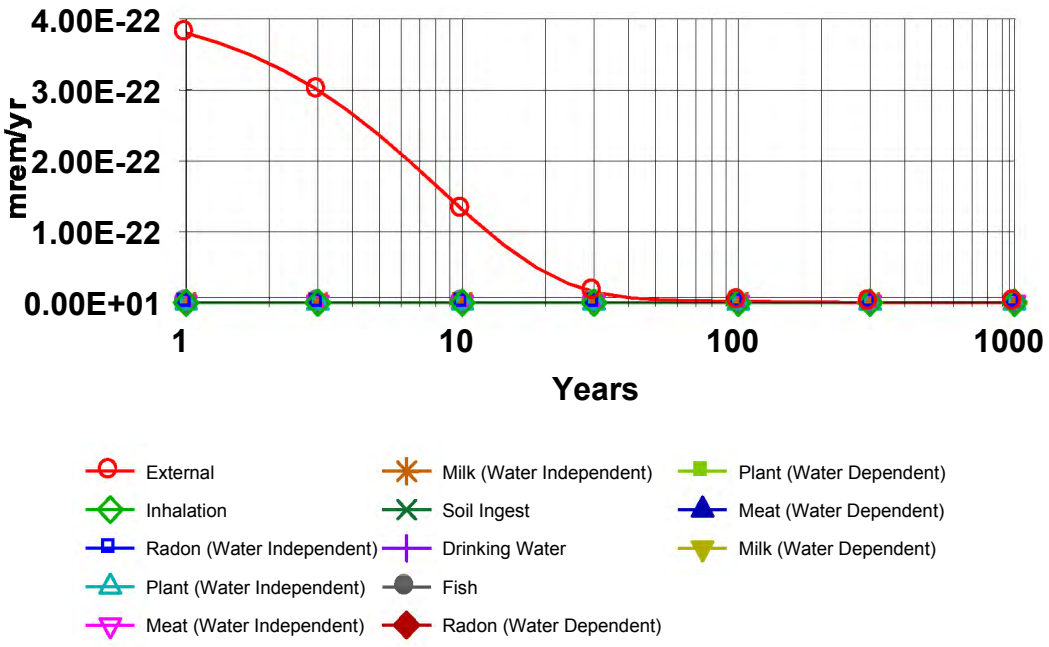


N Tunnel Muckpile Dose by All Radionuclides Summed and All Pathways Summed (13.5 ft Data)

Figure 7-1. CAU 477 Scenario B: Dose Rate Per Year All Radionuclides Summed, All Pathways Summed



N Tunnel Muckpile Dose by All Radionuclides Summed by Component Pathways (6ft Data)



N Tunnel Muckpile Dose by All Radionuclides Summed by Component Pathways (13.5ft Data)

Figure 7-2. CAU 477 Scenario B: Annual Dose All Radionuclides Summed, Component Pathways

Table 7-2. Maximum Dose Contributions for CAU 477 Using Scenario B (mrem/yr)

Layer 6 ft at Approximately Year 200

Radionuclide	Ground		Inhalation		Soil		Total	
	Annual Dose	Fraction	Annual Dose	Fraction	Annual Dose	Fraction	Annual Dose	Fraction
Americium-241	2.406E-04	0.0041	5.648E-04	0.0095	2.711E-04	0.0046	1.077E-03	0.0182
Cerium-144	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cobalt-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Europium-155	7.371E-13	0.0000	6.106E-17	0.0000	1.321E-16	0.0000	7.373E-13	0.0000
Uranium-235	5.379E+02	0.9084	3.809E-03	0.0643	5.367E-04	0.0091	5.813E-02	0.9818
Total	5.403E-02	0.9125	4.373E-03	0.0739	8.078E-04	0.0136	5.921E-02	1.0000

Layer 13.5 ft at Year 0

Radionuclide	Ground		Inhalation		Soil		Total	
	Annual Dose	Fraction	Annual Dose	Fraction	Annual Dose	Fraction	Annual Dose	Fraction
Cobalt-60	4.230E-22	0.9878	0.000E+00	0.0000	0.000E+00	0.0000	4.230E-22	0.9878
Cesium-134	1.668E-26	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.668E-26	0.0000
Cesium-137	5.191E-24	0.0121	0.000E+00	0.0000	0.000E+00	0.0000	5.191E-24	0.0121
Plutonium-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Plutonium-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ruthenium-106	8.487E-28	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.487E-28	0.0000
Animony-125	2.611E-28	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.611E-28	0.0000
Total	4.282E-22	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.282E-22	1.0000

Table 7-3. CAU 477 Sum of Fractions and Proportional Scaling

Layer 6 ft

Radionuclide	Initial Radionuclide Concentration (pCi/g)	Contribution %	Single Radionuclide Guidelines (pCi/g)	Ratio for Single Radionuclide Guideline	Mixture Radionuclides Guidelines	Ratio for Mixture Radionuclide Guidelines
Americium-241	690	62.70	1.6000E+07	4.3125E-05	7.0726E+14	4.4204E+07
Cerium-144	94	08.54	3.1900E+15	2.9467E-14	9.6351E+13	3.0204E-02
Cobalt-57	17	1.54	8.4650E+15	2.0083E-15	1.7425E+13	2.0585E-03
Europium-155	70	20.89	4.6520E+14	4.9441E-13	2.3575E+14	5.0678E-01
Uranium-235	230	6.36	3.0100E+04	2.3256E-03	7.1751E+13	2.3837E+09
Total		100		2.3687E-03*		2.4279E+09

*unity < 1

Layer 13.5 ft

Radionuclide	Initial Radionuclide Concentration (pCi/g)	Contribution %	Single Radionuclide Guidelines (pCi/g)	Ratio for Single Radionuclide Guideline	Mixture Radionuclides Guidelines	Ratio for Mixture Radionuclide Guidelines
Cobalt-60	0.73	0.05	1.1320E+15	6.4488E-16	4.2620E+22	3.7650E+07
Cesium-134	0.53	0.04	1.2950E+15	4.0927E-16	3.0943E+22	2.3895E+07
Cesium-137	1340	99.25	8.7040E+13	1.5395E-11	7.8234E+25	8.9883E+11
Plutonium-238	0.272	0.02	1.7120E+13	1.5888E-14	1.5880E+22	9.2760E+08
Plutonium-239	0.55	0.04	6.2140E+10	8.8510E-12	3.2111E+22	5.1676E+11
Ruthenium-106	5.3	0.39	3.3480E+15	1.5830E-15	3.0943E+23	9.2424E+07
Antimony-125	2.7	0.20	1.0330E+15	2.6137E-15	1.5764E+23	1.5260E+08
Total		100		2.4267E-11*		1.4168E+12

*unity < 1

Table 7-4. Residual Radioactive Material Guidelines for Single Radionuclides and Radionuclide Mixtures*

Radionuclides	Guidelines by Layer 6 ft (pCi/g)		Guidelines by Layer 13.5 ft (pCi/g)	
	Mixture Radionuclide Guidelines	Single Radionuclide Guidelines	Mixture Radionuclide Guidelines	Single Radionuclide Guidelines
Americium (Am) -241	7.0726E+14	1.6000E+07	NA	NA
Cerium (Ce) -144	9.6351E+13	3.1900E+15	NA	NA
Cesium (Cs) -134	NA	NA	3.0943E+22	1.2950E+15
Cesium (Cs) -137	NA	NA	7.8234E+25	8.7040E+13
Cobalt (Co) -57	1.7425E+13	8.4650E+15	NA	NA
Cobalt (Co) -60	NA	NA	4.2620E+22	1.1320E+15
Europium (Eu) -155	2.3575E+14	4.6520E+14	NA	NA
Plutonium (Pu) -238	NA	NA	1.5880E+22	1.7120E+13
Plutonium (Pu) -239	NA	NA	3.2111E+22	6.2140E+10
Ruthenium (Ru) -106	NA	NA	3.0943E+23	3.3480E+15
Uranium (U) -235	7.1751E+13	3.0100E+04	NA	NA
Antimony (Sb) -125	NA	NA	1.5764E+23	1.0330E+15

*Single radionuclide guidelines apply to areas uniformly contaminated with a single radionuclide. The mixture radionuclide guidelines apply to areas uniformly contaminated with a mixture of radionuclides. The FALs for CAU 477 are the radionuclide guidelines for single radionuclides (i.e., Single Radionuclide Guidelines columns).

8.0 References

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Exhibit A

RESRAD Parameters Used for Analysis of CAU 477 Site

Exhibit A

RESRAD Parameters Used for Analysis of CAU 477 Site

The parametric values used in the RESRAD code for the analysis of the CAU 477 site are listed in Table A.1. Some parameters are site specific, while other values are default RESRAD values. The dose conversion factors used for inhalation and ingestion were the default FGR 13 morbidity values and correspond to the guidance and recommendations per the August 9, 2002, memorandum from A. Lawrence, Office of Environmental Policy & Guidance, to Distribution, titled "Radiation Risk Estimation from Total Effective Dose Equivalents (TEDEs)" (EH-412-2002-1) (Lawrence, 2002).

Table A.1 RESRAD Parameters

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Parameter	Units	CAU 477	Defaults	Reference/Rationale
R011 Contaminated Zone				
Area of CZ	m^2	1.00E+02	1.000E+04	10x10 m hot spot
Thickness of CZ	m	1.200E+00	2.000E+00	Maximum depth from contaminated samples
Length Parallel to Aquifer Flow	m	not used	1.000E+02	Not Used
Radiation Dose Limit	mrem/yr	2.5E+001	2.5E+001	RESRAD Default (Yu, et al., 1993)
Elapsed Time Since Placement of Material	yr	0.0	0.0	RESRAD Default
R012 Initial Principal Radionuclide				
Principal radionuclides	pCi/g	See Table 7.2	0.0	Site-specific

Table A.1 RESRAD Parameters

(Page 2 of 6)

Parameter	Units	CAU 477	Defaults	Reference/Rationale
R013 Cover and Contaminated Zone Hydrological Data				
Cover Depth	m	0.0	0.0	No Cover Assumed
Density of Cover Material	g/cm^3	not used	1.5	No Cover Assumed
Cover Depth Erosion Rate	m/yr	not used	1.000E-03	No Cover Assumed
Density of Contaminated Zone	g/cm^3	1.5	1.5	RESRAD Default
Contamination Zone Erosion Rate	m/yr	1.000E-03	1.000E-03	RESRAD Default
Contaminated Zone Total Porosity	-	4.000E-01	4.000E-01	RESRAD Default
Contaminated Zone Field Capacity	-	2.000E-01	2.000E-01	RESRAD Default
Contaminated Zone Hydraulic Conductivity	m/yr	1.000E+01	1.000E+01	RESRAD Default
Contaminated Zone b Parameter	-	5.300E+00	5.300E+00	RESRAD Default
Average Annual Wind Speed	m/sec	3.4	2.000E+00	Data from Air Resource Laboratory (2005)
Humidity in Air	g/m^3	not used	8.000E+00	Not used
Evapotranspiration Coefficient	-	5.000E-01	5.000E-01	RESRAD Default
Precipitation	m/yr	3.260E-01	1.000E+00	Data from Air Resources Laboratory
Irrigation	m/yr	2.000E-01	2.000E-01	RESRAD Default
Irrigation Mode	-	overhead	overhead	RESRAD Default
Runoff Coefficient	-	4.000E-01	2.000E-01	Open Sandy Loam 30% impervious Table 10.1 (Yu, et al., 1993)
Watershed Area for Nearby Stream or Pond	m^2	not used	1.000E+06	Not used
Accuracy for Water/Soil Computations	-	not used	1.000E-03	Not used

Table A.1 RESRAD Parameters
(Page 3 of 6)

Parameter	Units	CAU 477	Defaults	Reference/Rationale
R014 Saturated Zone Hydrological Data				
Density of Saturated Zone	g/cm^3	not used	1.500E+00	Not used
Saturated Zone Total Porosity	-	not used	4.000E-01	Not used
Saturated Zone Effective Porosity	-	not used	2.000E-01	Not used
Saturated Zone Field Capacity	-	not used	2.000E-01	Not used
Saturated Zone Hydraulic Conductivity	m/yr	not used	1.000E+02	Not used
Saturated Zone Hydraulic Gradient	-	not used	2.000E-02	Not used
Saturated Zone b Parameter	-	not used	5.300E+00	Not used
Water Table Drop Rate	m/yr	not used	1.000E-03	Not used
Well Pump Intake Depth	m	not used	1.000E+01	Not used
Model: Nondispersion or Mass-Balance	-	not used	ND	Not used
Well Pumping Rate	m^3/yr	not used	2.500E+02	Not used
R015 Uncontaminated and Unsaturated Strata Hydrological Data				
Number of Unsaturated Zone Strata	-	not used	1	Not used
Thickness	m	not used	4.000E+00	Not used
Soil Density	g/cm^3	not used	1.500E+00	Not used
Total Porosity	-	not used	4.000E-01	Not used
Effective Porosity	-	not used	2.000E-01	Not used
Field Capacity	-	not used	2.000E-01	Not used
Soil-specific b Parameter	-	not used	5.300E+00	Not used
Hydraulic Conductivity	m/yr	not used	1.000E+01	Not used

Table A.1 RESRAD Parameters

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Parameter	Units	CAU 477	Defaults	Reference/Rationale
R016 Distribution Coefficients and Leach Rates				
Contaminated Zone K_d (all Zones)	cm^3/g			RESRAD Default
Saturated Leach Rate	/yr	0.0	0.0	Not used
Solubility Constant	-	0.0	0.0	Not used
R017 Inhalation and External Gamma				
Inhalation Rate	m^3/yr	1.230E+04	8.400E+03	RESRAD Default and for an individual performing outdoor activities, a typical activity mix can consist of 37% at a moderate activity level, 28% at both resting and light activity levels, and 7% at a heavy activity level, which results in a 1.4 m^3/h (12,300 m^3/yr) inhalation rate. (Yu, et al., 1993)
Mass Loading for Inhalation	g/m^3	6.00E-04	1E-04	The estimated mass loading for construction activities. (Yu, et al., 1993)
Exposure Duration	yr	25	30	Standard for Industrial/Commercial Scenario
Shielding Factor Inhalation	-	1.0	0.4	Assumes no indoor time fraction
Shielding Factor External Gamma	-	1.0	0.7	Assumes no indoor time fraction
Fraction of Time Spent Indoors	-	0.0	0.5	Assumes no indoor time fraction
Fraction of Time Spent Outdoors	-	0.038	0.25	Scenario specific based on Industrial/ Commercial Use Scenarios for standard occupancy and low occupancy.
Shape Factor	-	1.0	1.0	RESRAD Default
R018 Ingestion Pathway Data, Dietary Parameters				
Fruits, Vegetables, and Grain Consumption	kg/yr	not used	1.600E+02	Not used
Leafy Vegetable Consumption	kg/yr	not used	1.400E+01	Not used
Milk Consumption	L/yr	not used	9.200E+01	Not used
Meat and Poultry Consumption	kg/yr	not used	6.300E+01	Not used

Table A.1 RESRAD Parameters
(Page 5 of 6)

Parameter	Units	CAU 477	Defaults	Reference/Rationale
Fish Consumption	kg/yr	not used	5.400E+00	Not used
Other Seafood Consumption	kg/yr	not used	9.000E-01	Not used
Soil Ingestion Rate	g/yr	1.752E+02	36.5	EPA, 1991; 480 mg/day
Drinking Water Intake	L/yr	not used	5.100E+02	Not used
Drinking Water Contaminated Fraction	-	not used	1.000E+00	Not used
Household Water Contaminated Fraction	-	not used	1.000E+00	Not used
Livestock Water Contaminated Fraction	-	not used	1.000E+00	Not used
Irrigation Water Contaminated Fraction	-	not used	1.000E+00	Not used
Aquatic Food Contamination Fraction	-	not used	5.000E-01	Not used
Plant Food Contamination Fraction	-	not used	-1	Not used
Meat Contamination Fraction	-	not used	-1	Not used
Milk Contamination Fraction	-	not used	-1	Not used
R019 Ingestion Pathway Data, Nondietary				
Livestock Fodder Intake for Meat	kg/day	not used	6.800E+01	Not used
Livestock Fodder Intake for Milk	kg/day	not used	5.500E+01	Not used
Livestock Water Intake for Meat	L/day	not used	5.000E+01	Not used
Livestock Water Intake for Milk	L/day	not used	1.600E+02	Not used
Livestock Soil Intake	kg/day	not used	5.000E-01	Not used
Mass Loading for Foliar Deposition	g/m^3	not used	1.000E-04	Not used
Depth of Soil Mixing Layer	m	1.500E-01	1.500E-01	RESRAD Default
Depth of Roots	m	not used	9.000E-01	Not used

Table A.1 RESRAD Parameters
(Page 6 of 6)

Parameter	Units	CAU 477	Defaults	Reference/Rationale
Drinking Water Fraction from Groundwater	-	not used	1.000E+00	Not used
Household Water Fraction from Groundwater	-	not used	1.000E+00	Not used
Livestock Water Fraction from Groundwater	-	not used	1.000E+00	Not used
Irrigation Fraction from Groundwater	-	not used	1.000E+00	Not used
R021 Radon				
Radon Parameters Not Used				Not used

cm^3/g = Cubic centimeters per gram
g/cm^3 = Grams per cubic centimeter
g/m^3 = Grams per cubic meter
g/yr = Grams per year
kg/day = Kilograms per day
kg/yr = Kilograms per year
L/day = Liters per day
L/yr = Liters per year
m = Meter
m^2 = Square meter
m/sec = Meters per second
N/A = Not applicable
m/yr = Meters per year
m^3/h = Cubic meters per hour
m^3/yr = Cubic meters per year
mg.day = Milligrams per day
mrem/yr = Millirem per year
pCi/g = Picocuries per gram
yr = Year
/yr = Per year
UCL = Upper confidence level

Exhibit B

RESRAD Summary Report: CAU 477

(Layer 6 ft, 20 pages;
Layer 13.5 ft, 24 pages)

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.724E+00	6.700E+00	DCF2(1)
B-1	Am-241	4.440E-01	4.440E-01	DCF2(2)
B-1	Ce-144+D	3.740E-04	3.740E-04	DCF2(3)
B-1	Co-57	9.070E-06	9.070E-06	DCF2(4)
B-1	Eu-155	4.140E-05	4.140E-05	DCF2(5)
B-1	Np-237+D	5.400E-01	5.400E-01	DCF2(6)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(7)
B-1	Th-229+D	2.169E+00	2.150E+00	DCF2(8)
B-1	U-233	1.350E-01	1.350E-01	DCF2(9)
B-1	U-235+D	1.230E-01	1.230E-01	DCF2(10)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	1.480E-02	1.410E-02	DCF3(1)
D-1	Am-241	3.640E-03	3.640E-03	DCF3(2)
D-1	Ce-144+D	2.112E-05	2.100E-05	DCF3(3)
D-1	Co-57	1.180E-06	1.180E-06	DCF3(4)
D-1	Eu-155	1.530E-06	1.530E-06	DCF3(5)
D-1	Np-237+D	4.444E-03	4.440E-03	DCF3(6)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(7)
D-1	Th-229+D	4.027E-03	3.530E-03	DCF3(8)
D-1	U-233	2.890E-04	2.890E-04	DCF3(9)
D-1	U-235+D	2.673E-04	2.660E-04	DCF3(10)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)
D-34				
D-34	Am-241 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(2,1)
D-34	Am-241 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-05	5.000E-05	RTF(2,2)
D-34	Am-241 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-06	2.000E-06	RTF(2,3)
D-34				
D-34	Ce-144+D , plant/soil concentration ratio, dimensionless	2.000E-03	2.000E-03	RTF(3,1)
D-34	Ce-144+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(3,2)
D-34	Ce-144+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-05	5.000E-05	RTF(3,3)
D-34				
D-34	Co-57 , plant/soil concentration ratio, dimensionless	8.000E-02	8.000E-02	RTF(4,1)
D-34	Co-57 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-02	2.000E-02	RTF(4,2)
D-34	Co-57 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(4,3)
D-34				
D-34	Eu-155 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(5,1)
D-34	Eu-155 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-03	2.000E-03	RTF(5,2)
D-34	Eu-155 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-05	5.000E-05	RTF(5,3)
D-34				
D-34	Np-237+D , plant/soil concentration ratio, dimensionless	2.000E-02	2.000E-02	RTF(6,1)
D-34	Np-237+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(6,2)
D-34	Np-237+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(6,3)
D-34				

Dose Conversion Factor (and Related) Parameter Summary (continued)
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(7,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(7,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(7,3)
D-34				
D-34	Th-229+D , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(8,1)
D-34	Th-229+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(8,2)
D-34	Th-229+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(8,3)
D-34				
D-34	U-233 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(9,1)
D-34	U-233 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(9,2)
D-34	U-233 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(9,3)
D-34				
D-34	U-235+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(10,1)
D-34	U-235+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(10,2)
D-34	U-235+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(10,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ac-227+D , fish	1.500E+01	1.500E+01	BIOFAC(1,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Am-241 , fish	3.000E+01	3.000E+01	BIOFAC(2,1)
D-5	Am-241 , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(2,2)
D-5				
D-5	Ce-144+D , fish	3.000E+01	3.000E+01	BIOFAC(3,1)
D-5	Ce-144+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(3,2)
D-5				
D-5	Co-57 , fish	3.000E+02	3.000E+02	BIOFAC(4,1)
D-5	Co-57 , crustacea and mollusks	2.000E+02	2.000E+02	BIOFAC(4,2)
D-5				
D-5	Eu-155 , fish	5.000E+01	5.000E+01	BIOFAC(5,1)
D-5	Eu-155 , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(5,2)
D-5				
D-5	Np-237+D , fish	3.000E+01	3.000E+01	BIOFAC(6,1)
D-5	Np-237+D , crustacea and mollusks	4.000E+02	4.000E+02	BIOFAC(6,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC(7,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC(7,2)
D-5				
D-5	Th-229+D , fish	1.000E+02	1.000E+02	BIOFAC(8,1)
D-5	Th-229+D , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(8,2)
D-5				
D-5	U-233 , fish	1.000E+01	1.000E+01	BIOFAC(9,1)
D-5	U-233 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(9,2)
D-5				
D-5	U-235+D , fish	1.000E+01	1.000E+01	BIOFAC(10,1)
D-5	U-235+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(10,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter		User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)		1.000E+02	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)		1.500E-01	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)		not used	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)		2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)		0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)		1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)		3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)		1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)		3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)		1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)		3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)		1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)		not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)		not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g):	Am-241	6.900E+02	0.000E+00	---	S1(2)
R012	Initial principal radionuclide (pCi/g):	Ce-144	9.400E+01	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g):	Co-57	1.700E+01	0.000E+00	---	S1(4)
R012	Initial principal radionuclide (pCi/g):	Eu-155	2.300E+02	0.000E+00	---	S1(5)
R012	Initial principal radionuclide (pCi/g):	U-235	7.000E+01	0.000E+00	---	S1(10)
R012	Concentration in groundwater (pCi/L):	Am-241	not used	0.000E+00	---	W1(2)
R012	Concentration in groundwater (pCi/L):	Ce-144	not used	0.000E+00	---	W1(3)
R012	Concentration in groundwater (pCi/L):	Co-57	not used	0.000E+00	---	W1(4)
R012	Concentration in groundwater (pCi/L):	Eu-155	not used	0.000E+00	---	W1(5)
R012	Concentration in groundwater (pCi/L):	U-235	not used	0.000E+00	---	W1(10)
R013	Cover depth (m)		2.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)		1.500E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)		1.000E-02	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)		1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)		1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity		4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity		2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)		1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter		5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)		5.170E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)		not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient		5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)		3.045E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)		2.000E-01	2.000E-01	---	RI
R013	Irrigation mode		overhead	overhead	---	IDITCH
R013	Runoff coefficient		4.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)		not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations		not used	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)		not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity		not used	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity		not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity		not used	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)		not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient		not used	2.000E-02	---	HGWT

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	not used	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Am-241				
R016	Contaminated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	not used	2.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	not used	2.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.210E-02	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for Ce-144				
R016	Contaminated zone (cm**3/g)	1.000E+03	1.000E+03	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+03	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+03	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	8.503E-04	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for Co-57				
R016	Contaminated zone (cm**3/g)	1.000E+03	1.000E+03	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+03	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+03	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	8.503E-04	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for Eu-155				
R016	Contaminated zone (cm**3/g)	-1.000E+00	-1.000E+00	8.249E+02	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	not used	-1.000E+00	---	DCNUCU(5,1)
R016	Saturated zone (cm**3/g)	not used	-1.000E+00	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.031E-03	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R016	Distribution coefficients for U-235				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(10)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(10,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(10)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.694E-02	ALEACH(10)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(10)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for daughter Ac-227				
R016	Contaminated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	not used	2.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	not used	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.210E-02	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for daughter Np-237				
R016	Contaminated zone (cm**3/g)	-1.000E+00	-1.000E+00	2.574E+02	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	not used	-1.000E+00	---	DCNUCU(6,1)
R016	Saturated zone (cm**3/g)	not used	-1.000E+00	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.301E-03	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for daughter Pa-231				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(7,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.694E-02	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)
R016	Distribution coefficients for daughter Th-229				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(8)
R016	Unsaturated zone 1 (cm**3/g)	not used	6.000E+04	---	DCNUCU(8,1)
R016	Saturated zone (cm**3/g)	not used	6.000E+04	---	DCNUCS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.417E-05	ALEACH(8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(8)
R016	Distribution coefficients for daughter U-233				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(9)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(9,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(9)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.694E-02	ALEACH(9)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(9)
R017	Inhalation rate (m**3/yr)	1.230E+04	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	6.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	2.500E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	1.000E+00	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	1.000E+00	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	0.000E+00	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	3.800E-02	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	1.752E+02	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	0.000E+00	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

Contaminated Zone Dimensions

Area:	100.00 square meters
Thickness:	0.15 meters
Cover Depth:	2.00 meters

Initial Soil Concentrations, pCi/g

Am-241	6.900E+02
Ce-144	9.400E+01
Co-57	1.700E+01
Eu-155	2.300E+02
U-235	7.000E+01

0

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	2.439E-11	1.126E-11	2.400E-12	1.077E-14	2.696E-15	4.545E-10	6.532E-03	0.000E+00
M(t):	9.755E-13	4.504E-13	9.600E-14	4.309E-16	1.078E-16	1.818E-11	2.613E-04	0.000E+00

0Maximum TDOSE(t): 5.921E-02 mrem/yr at t = 199.8 ñ 0.4 years
0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.998E+02 years
0 Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	2.406E-04	0.0041	5.648E-04	0.0095	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.711E-04	0.0046
Ce-144	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Co-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Eu-155	7.371E-13	0.0000	6.106E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.321E-16	0.0000
U-235	5.379E-02	0.9084	3.809E-03	0.0643	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.367E-04	0.0091
Total	5.403E-02	0.9125	4.373E-03	0.0739	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.078E-04	0.0136

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.998E+02 years
0 Water Dependent Pathways

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.077E-03	0.0182
Ce-144	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Co-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Eu-155	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.373E-13	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.813E-02	0.9818
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.921E-02	1.0000

0*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

0 Water Independent Pathways (Inhalation excludes radon)

0 Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	1.745E-21	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ce-144	2.439E-11	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Co-57	3.001E-22	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Eu-155	1.898E-25	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	2.003E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.439E-11	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

0 Water Dependent Pathways

0 Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.745E-21	0.0000
Ce-144	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.439E-11	1.0000
Co-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.001E-22	0.0000
Eu-155	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.898E-25	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.003E-18	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.439E-11	1.0000

0*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years
Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Am-241	6.003E-21	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ce-144	1.126E-11	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Co-57	1.497E-22	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Eu-155	2.196E-25	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	2.606E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.126E-11	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years
Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.003E-21	0.0000
Ce-144	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.126E-11	1.0000
Co-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.497E-22	0.0000
Eu-155	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.196E-25	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.606E-18	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.126E-11	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

0 Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Am-241	1.896E-20	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ce-144	2.400E-12	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Co-57	3.726E-23	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Eu-155	2.939E-25	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	4.886E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.400E-12	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

0 Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.896E-20	0.0000
Ce-144	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.400E-12	1.0000
Co-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.726E-23	0.0000
Eu-155	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.939E-25	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.886E-18	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.400E-12	1.0000

0*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Am-241	1.673E-19	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ce-144	1.073E-14	0.9963	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Co-57	2.865E-25	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Eu-155	8.152E-25	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	3.964E-17	0.0037	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.077E-14	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.673E-19	0.0000
Ce-144	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.073E-14	0.9963
Co-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.865E-25	0.0000
Eu-155	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.152E-25	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.964E-17	0.0037
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.077E-14	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years
Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Am-241	1.105E-17	0.0041	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ce-144	2.078E-21	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Co-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Eu-155	1.503E-23	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	2.685E-15	0.9959	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.696E-15	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years
Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.105E-17	0.0041
Ce-144	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.078E-21	0.0000
Co-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Eu-155	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.503E-23	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.685E-15	0.9959
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.696E-15	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Am-241	2.924E-12	0.0064	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ce-144	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Co-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Eu-155	4.046E-19	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	4.516E-10	0.9936	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.545E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.924E-12	0.0064
Ce-144	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Co-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Eu-155	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.046E-19	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.516E-10	0.9936
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.545E-10	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Am-241	4.075E-05	0.0062	6.432E-06	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.094E-06	0.0005
Ce-144	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Co-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Eu-155	4.215E-19	0.0000	1.518E-23	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.284E-23	0.0000
U-235	6.197E-03	0.9487	2.482E-04	0.0380	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.632E-05	0.0056
Total	6.238E-03	0.9550	2.546E-04	0.0390	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.942E-05	0.0060

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.028E-05	0.0077
Ce-144	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Co-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Eu-155	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.216E-19	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.482E-03	0.9923
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.532E-03	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years
Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ce-144	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Co-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Eu-155	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years
Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ce-144	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Co-57	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Eu-155	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

0 Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Am-241	Am-241	1.000E+00	2.803E-44	4.344E-44	1.037E-43	2.028E-42	1.012E-38	8.906E-26	7.393E-09	0.000E+00
Am-241	Np-237+D	1.000E+00	2.529E-24	8.700E-24	2.748E-23	2.424E-22	1.601E-20	4.238E-15	6.547E-08	0.000E+00
Am-241	U-233	1.000E+00	9.522E-36	7.831E-35	5.955E-34	1.970E-32	7.204E-30	5.100E-23	5.548E-13	0.000E+00
Am-241	Th-229+D	1.000E+00	2.522E-30	4.131E-29	5.871E-28	3.190E-26	6.241E-24	4.133E-19	9.597E-13	0.000E+00
Am-241	äDSR(j)		2.529E-24	8.700E-24	2.748E-23	2.425E-22	1.602E-20	4.238E-15	7.286E-08	0.000E+00
0Ce-144+D	Ce-144+D	1.000E+00	2.594E-13	1.198E-13	2.553E-14	1.142E-16	2.211E-23	0.000E+00	0.000E+00	0.000E+00
0Co-57	Co-57	1.000E+00	1.765E-23	8.807E-24	2.192E-24	1.686E-26	1.536E-32	0.000E+00	0.000E+00	0.000E+00
0Eu-155	Eu-155	1.000E+00	8.254E-28	9.549E-28	1.278E-27	3.544E-27	6.535E-26	1.759E-21	1.833E-21	0.000E+00
0U-235+D	U-235+D	1.000E+00	2.817E-20	3.407E-20	4.983E-20	1.885E-19	8.435E-18	5.058E-12	9.091E-05	0.000E+00
U-235+D	Pa-231	1.000E+00	5.647E-23	1.949E-22	6.194E-22	5.565E-21	3.735E-19	7.318E-14	4.009E-07	0.000E+00
U-235+D	Ac-227+D	1.000E+00	3.856E-22	2.964E-21	1.936E-20	3.722E-19	2.954E-17	1.320E-12	1.281E-06	0.000E+00
U-235+D	äDSR(j)		2.862E-20	3.723E-20	6.980E-20	5.663E-19	3.835E-17	6.451E-12	9.260E-05	0.000E+00

The DSR includes contributions from associated (half-life ó 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

0Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Am-241	*3.431E+12	*3.431E+12	*3.431E+12	*3.431E+12	*3.431E+12	*3.431E+12	3.431E+08	*3.431E+12
Ce-144	9.636E+13	2.087E+14	9.791E+14	*3.191E+15	*3.191E+15	*3.191E+15	*3.191E+15	*3.191E+15
Co-57	*8.465E+15	*8.465E+15	*8.465E+15	*8.465E+15	*8.465E+15	*8.465E+15	*8.465E+15	*8.465E+15
Eu-155	*4.652E+14	*4.652E+14	*4.652E+14	*4.652E+14	*4.652E+14	*4.652E+14	*4.652E+14	*4.652E+14
U-235	*2.161E+06	*2.161E+06	*2.161E+06	*2.161E+06	*2.161E+06	*2.161E+06	2.700E+05	*2.161E+06

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 199.8 ñ 0.4 years

0Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Am-241	6.900E+02	199.7 ñ 0.4	1.563E-06	1.600E+07	1.560E-06	1.602E+07
Ce-144	9.400E+01	0.000E+00	2.594E-13	9.636E+13	0.000E+00	*3.191E+15
Co-57	1.700E+01	0.000E+00	1.765E-23	*8.465E+15	0.000E+00	*8.465E+15
Eu-155	2.300E+02	199.6 ñ 0.4	3.250E-15	*4.652E+14	3.206E-15	*4.652E+14
U-235	7.000E+01	199.8 ñ 0.4	8.305E-04	3.010E+04	8.305E-04	3.010E+04

*At specific activity limit

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

0Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Am-241	Am-241	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.145E-23	5.101E-06	0.000E+00
0Np-237	Am-241	1.000E+00	1.745E-21	6.003E-21	1.896E-20	1.673E-19	1.105E-17	2.924E-12	4.517E-05	0.000E+00
0U-233	Am-241	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.971E-27	3.519E-20	3.828E-10	0.000E+00
0Th-229	Am-241	1.000E+00	1.740E-27	2.851E-26	4.051E-25	2.201E-23	4.307E-21	2.852E-16	6.622E-10	0.000E+00
0Ce-144	Ce-144	1.000E+00	2.439E-11	1.126E-11	2.400E-12	1.073E-14	2.078E-21	0.000E+00	0.000E+00	0.000E+00
0Co-57	Co-57	1.000E+00	3.001E-22	1.497E-22	3.726E-23	2.865E-25	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0Eu-155	Eu-155	1.000E+00	1.898E-25	2.196E-25	2.939E-25	8.152E-25	1.503E-23	4.046E-19	4.216E-19	0.000E+00
0U-235	U-235	1.000E+00	1.972E-18	2.385E-18	3.488E-18	1.319E-17	5.905E-16	3.541E-10	6.364E-03	0.000E+00
0Pa-231	U-235	1.000E+00	3.953E-21	1.364E-20	4.336E-20	3.895E-19	2.615E-17	5.123E-12	2.806E-05	0.000E+00
0Ac-227	U-235	1.000E+00	2.699E-20	2.075E-19	1.355E-18	2.606E-17	2.068E-15	9.237E-11	8.966E-05	0.000E+00

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

0Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Am-241	Am-241	1.000E+00	6.900E+02	6.605E+02	6.052E+02	4.457E+02	1.860E+02	8.724E+00	1.395E-03	7.202E-17
0Np-237	Am-241	1.000E+00	0.000E+00	2.183E-04	6.252E-04	1.779E-03	3.519E-03	3.906E-03	2.054E-03	2.037E-04
0U-233	Am-241	1.000E+00	0.000E+00	4.784E-10	4.127E-09	3.962E-08	2.393E-07	7.941E-07	6.419E-07	6.529E-08
0Th-229	Am-241	1.000E+00	0.000E+00	1.514E-14	3.960E-13	1.314E-11	2.635E-10	3.996E-09	1.874E-08	3.340E-08
0Ce-144	Ce-144	1.000E+00	9.400E+01	3.855E+01	6.483E+00	1.265E-02	2.290E-10	1.827E-37	0.000E+00	0.000E+00
0Co-57	Co-57	1.000E+00	1.700E+01	6.671E+00	1.027E+00	1.472E-03	1.104E-11	4.038E-40	0.000E+00	0.000E+00
0Eu-155	Eu-155	1.000E+00	2.300E+02	1.998E+02	1.508E+02	5.628E+01	3.369E+00	1.769E-04	1.047E-16	0.000E+00
0U-235	U-235	1.000E+00	7.000E+01	6.882E+01	6.653E+01	5.909E+01	4.211E+01	1.286E+01	4.343E-01	3.073E-06
0Pa-231	U-235	1.000E+00	0.000E+00	1.456E-03	4.223E-03	1.250E-02	2.672E-02	2.719E-02	2.748E-03	6.434E-08
0Ac-227	U-235	1.000E+00	0.000E+00	2.274E-05	1.906E-04	1.660E-03	7.776E-03	1.253E-02	1.446E-03	3.531E-08

THF(i) is the thread fraction of the parent nuclide.
0RESCALC.EXE execution time = 3.05 seconds

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.724E+00	6.700E+00	DCF2(1)
B-1	Co-60	2.190E-04	2.190E-04	DCF2(2)
B-1	Cs-134	4.620E-05	4.620E-05	DCF2(3)
B-1	Cs-137+D	3.190E-05	3.190E-05	DCF2(4)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(5)
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(6)
B-1	Pu-238	3.920E-01	3.920E-01	DCF2(7)
B-1	Pu-239	4.290E-01	4.290E-01	DCF2(9)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(10)
B-1	Ru-106+D	4.770E-04	4.770E-04	DCF2(11)
B-1	Sb-125+D	1.386E-05	1.220E-05	DCF2(12)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(13)
B-1	U-234	1.320E-01	1.320E-01	DCF2(14)
B-1	U-235+D	1.230E-01	1.230E-01	DCF2(15)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	1.480E-02	1.410E-02	DCF3(1)
D-1	Co-60	2.690E-05	2.690E-05	DCF3(2)
D-1	Cs-134	7.330E-05	7.330E-05	DCF3(3)
D-1	Cs-137+D	5.000E-05	5.000E-05	DCF3(4)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(5)
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(6)
D-1	Pu-238	3.200E-03	3.200E-03	DCF3(7)
D-1	Pu-239	3.540E-03	3.540E-03	DCF3(9)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(10)
D-1	Ru-106+D	2.740E-05	2.740E-05	DCF3(11)
D-1	Sb-125+D	3.647E-06	2.810E-06	DCF3(12)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(13)
D-1	U-234	2.830E-04	2.830E-04	DCF3(14)
D-1	U-235+D	2.673E-04	2.660E-04	DCF3(15)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)
D-34				
D-34	Co-60 , plant/soil concentration ratio, dimensionless	8.000E-02	8.000E-02	RTF(2,1)
D-34	Co-60 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-02	2.000E-02	RTF(2,2)
D-34	Co-60 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(2,3)
D-34				
D-34	Cs-134 , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(3,1)
D-34	Cs-134 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.000E-02	3.000E-02	RTF(3,2)
D-34	Cs-134 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	8.000E-03	8.000E-03	RTF(3,3)
D-34				
D-34	Cs-137+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(4,1)
D-34	Cs-137+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.000E-02	3.000E-02	RTF(4,2)
D-34	Cs-137+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	8.000E-03	8.000E-03	RTF(4,3)
D-34				

Dose Conversion Factor (and Related) Parameter Summary (continued)
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(5,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(5,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(5,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(6,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(6,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(6,3)
D-34				
D-34	Pu-238 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(7,1)
D-34	Pu-238 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(7,2)
D-34	Pu-238 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-06	1.000E-06	RTF(7,3)
D-34				
D-34	Pu-239 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(9,1)
D-34	Pu-239 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(9,2)
D-34	Pu-239 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-06	1.000E-06	RTF(9,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(10,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(10,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(10,3)
D-34				
D-34	Ru-106+D , plant/soil concentration ratio, dimensionless	3.000E-02	3.000E-02	RTF(11,1)
D-34	Ru-106+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-03	2.000E-03	RTF(11,2)
D-34	Ru-106+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.300E-06	3.300E-06	RTF(11,3)
D-34				
D-34	Sb-125+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(12,1)
D-34	Sb-125+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(12,2)
D-34	Sb-125+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-04	1.000E-04	RTF(12,3)
D-34				
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(13,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(13,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(13,3)
D-34				
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(14,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(14,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(14,3)
D-34				
D-34	U-235+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(15,1)
D-34	U-235+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(15,2)
D-34	U-235+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(15,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ac-227+D , fish	1.500E+01	1.500E+01	BIOFAC(1,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Co-60 , fish	3.000E+02	3.000E+02	BIOFAC(2,1)
D-5	Co-60 , crustacea and mollusks	2.000E+02	2.000E+02	BIOFAC(2,2)
D-5				
D-5	Cs-134 , fish	2.000E+03	2.000E+03	BIOFAC(3,1)
D-5	Cs-134 , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(3,2)
D-5				

Dose Conversion Factor (and Related) Parameter Summary (continued)
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Menu	Parameter	Current Value	Base Case*	Parameter Name
D-5	Cs-137+D , fish	2.000E+03	2.000E+03	BIOFAC(4,1)
D-5	Cs-137+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(4,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC(5,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC(5,2)
D-5				
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(6,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(6,2)
D-5				
D-5	Pu-238 , fish	3.000E+01	3.000E+01	BIOFAC(7,1)
D-5	Pu-238 , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(7,2)
D-5				
D-5	Pu-239 , fish	3.000E+01	3.000E+01	BIOFAC(9,1)
D-5	Pu-239 , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(9,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(10,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(10,2)
D-5				
D-5	Ru-106+D , fish	1.000E+01	1.000E+01	BIOFAC(11,1)
D-5	Ru-106+D , crustacea and mollusks	3.000E+02	3.000E+02	BIOFAC(11,2)
D-5				
D-5	Sb-125+D , fish	1.000E+02	1.000E+02	BIOFAC(12,1)
D-5	Sb-125+D , crustacea and mollusks	1.000E+01	1.000E+01	BIOFAC(12,2)
D-5				
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC(13,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(13,2)
D-5				
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC(14,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(14,2)
D-5				
D-5	U-235+D , fish	1.000E+01	1.000E+01	BIOFAC(15,1)
D-5	U-235+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(15,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter		User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)		1.000E+02	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)		1.500E-01	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)		not used	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)		2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)		0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)		1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)		3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)		1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)		3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)		1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)		3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)		1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)		not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)		not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g):	Co-60	7.300E-01	0.000E+00	---	S1(2)
R012	Initial principal radionuclide (pCi/g):	Cs-134	5.300E-01	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g):	Cs-137	1.340E+03	0.000E+00	---	S1(4)
R012	Initial principal radionuclide (pCi/g):	Pu-238	2.720E-01	0.000E+00	---	S1(7)
R012	Initial principal radionuclide (pCi/g):	Pu-239	5.500E-01	0.000E+00	---	S1(9)
R012	Initial principal radionuclide (pCi/g):	Ru-106	5.300E+00	0.000E+00	---	S1(11)
R012	Initial principal radionuclide (pCi/g):	Sb-125	2.700E+00	0.000E+00	---	S1(12)
R012	Concentration in groundwater (pCi/L):	Co-60	not used	0.000E+00	---	W1(2)
R012	Concentration in groundwater (pCi/L):	Cs-134	not used	0.000E+00	---	W1(3)
R012	Concentration in groundwater (pCi/L):	Cs-137	not used	0.000E+00	---	W1(4)
R012	Concentration in groundwater (pCi/L):	Pu-238	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L):	Pu-239	not used	0.000E+00	---	W1(9)
R012	Concentration in groundwater (pCi/L):	Ru-106	not used	0.000E+00	---	W1(11)
R012	Concentration in groundwater (pCi/L):	Sb-125	not used	0.000E+00	---	W1(12)
R013	Cover depth (m)		4.110E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)		1.500E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)		1.000E-03	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)		1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)		1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity		4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity		2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)		1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter		5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)		5.170E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)		not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient		5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)		3.045E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)		2.000E-01	2.000E-01	---	RI
R013	Irrigation mode		overhead	overhead	---	IDITCH
R013	Runoff coefficient		4.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)		not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations		not used	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)		not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity		not used	4.000E-01	---	TPSZ

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Saturated zone effective porosity	not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	not used	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	not used	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	not used	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Co-60				
R016	Contaminated zone (cm**3/g)	1.000E+03	1.000E+03	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+03	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+03	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	8.503E-04	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for Cs-134				
R016	Contaminated zone (cm**3/g)	4.600E+03	4.600E+03	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	not used	4.600E+03	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	not used	4.600E+03	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.849E-04	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for Cs-137				
R016	Contaminated zone (cm**3/g)	4.600E+03	4.600E+03	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	not used	4.600E+03	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	not used	4.600E+03	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.849E-04	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for Pu-238				
R016	Contaminated zone (cm**3/g)	2.000E+03	2.000E+03	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	not used	2.000E+03	---	DCNUCU(7,1)
R016	Saturated zone (cm**3/g)	not used	2.000E+03	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.252E-04	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for Pu-239				
R016	Contaminated zone (cm**3/g)	2.000E+03	2.000E+03	---	DCNUCC(9)
R016	Unsaturated zone 1 (cm**3/g)	not used	2.000E+03	---	DCNUCU(9,1)
R016	Saturated zone (cm**3/g)	not used	2.000E+03	---	DCNUCS(9)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.252E-04	ALEACH(9)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(9)
R016	Distribution coefficients for Ru-106				
R016	Contaminated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCC(11)
R016	Unsaturated zone 1 (cm**3/g)	not used	0.000E+00	---	DCNUCU(11,1)
R016	Saturated zone (cm**3/g)	not used	0.000E+00	---	DCNUCS(11)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.266E+00	ALEACH(11)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(11)
R016	Distribution coefficients for Sb-125				
R016	Contaminated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCC(12)
R016	Unsaturated zone 1 (cm**3/g)	not used	0.000E+00	---	DCNUCU(12,1)
R016	Saturated zone (cm**3/g)	not used	0.000E+00	---	DCNUCS(12)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.266E+00	ALEACH(12)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(12)
R016	Distribution coefficients for daughter Ac-227				
R016	Contaminated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	not used	2.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	not used	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.210E-02	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for daughter Pa-231				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(5,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.694E-02	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+02	---	DCNUCU(6,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+02	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	8.488E-03	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for daughter Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(10)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU(10,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS(10)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.211E-02	ALEACH(10)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(10)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for daughter Th-230				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(13)
R016	Unsaturated zone 1 (cm**3/g)	not used	6.000E+04	---	DCNUCU(13,1)
R016	Saturated zone (cm**3/g)	not used	6.000E+04	---	DCNUCS(13)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.417E-05	ALEACH(13)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(13)
R016	Distribution coefficients for daughter U-234				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(14)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(14,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(14)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.694E-02	ALEACH(14)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(14)
R016	Distribution coefficients for daughter U-235				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(15)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(15,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(15)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.694E-02	ALEACH(15)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(15)
R017	Inhalation rate (m**3/yr)	1.230E+04	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	6.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	2.500E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	1.000E+00	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	1.000E+00	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	0.000E+00	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	3.800E-02	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	1.752E+02	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	0.000E+00	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

Contaminated Zone Dimensions

Area:	100.00 square meters
Thickness:	0.15 meters
Cover Depth:	4.11 meters

Initial Soil Concentrations, pCi/g

Co-60	7.300E-01
Cs-134	5.300E-01
Cs-137	1.340E+03
Pu-238	2.720E-01
Pu-239	5.500E-01
Ru-106	5.300E+00
Sb-125	2.700E+00

0

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	4.282E-22	3.801E-22	2.996E-22	1.313E-22	1.529E-23	2.105E-24	3.448E-25	2.969E-25
M(t):	1.713E-23	1.520E-23	1.198E-23	5.253E-24	6.117E-25	8.418E-26	1.379E-26	1.188E-26

0Maximum TDOSE(t): 4.282E-22 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

0 Water Independent Pathways (Inhalation excludes radon)

0	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	4.230E-22	0.9878	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-134	1.668E-26	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-137	5.191E-24	0.0121	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	8.487E-28	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sb-125	2.611E-28	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.282E-22	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

0 Water Dependent Pathways

0	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.230E-22	0.9878
Cs-134	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.668E-26	0.0000
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.191E-24	0.0121
Pu-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.487E-28	0.0000
Sb-125	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.611E-28	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.282E-22	1.0000

0*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

0 Water Independent Pathways (Inhalation excludes radon)

0	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	3.750E-22	0.9864	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-134	1.208E-26	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-137	5.144E-24	0.0135	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	6.077E-30	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sb-125	2.897E-30	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.801E-22	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

0 Water Dependent Pathways

0	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.750E-22	0.9864
Cs-134	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.208E-26	0.0000
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.144E-24	0.0135
Pu-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.077E-30	0.0000
Sb-125	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.897E-30	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.801E-22	1.0000

0*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

0 Water Independent Pathways (Inhalation excludes radon)

0	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	2.946E-22	0.9831	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-134	6.340E-27	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-137	5.052E-24	0.0169	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sb-125	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.996E-22	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

0 Water Dependent Pathways

0	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.946E-22	0.9831
Cs-134	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.340E-27	0.0000
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.052E-24	0.0169
Pu-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sb-125	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.996E-22	1.0000

0*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	1.266E-22	0.9639	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-134	6.638E-28	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-137	4.742E-24	0.0361	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sb-125	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.313E-22	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.266E-22	0.9639
Cs-134	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.638E-28	0.0000
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.742E-24	0.0361
Pu-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sb-125	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.313E-22	1.0000

0*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

0 Water Independent Pathways (Inhalation excludes radon)

0	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	1.133E-23	0.7412	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-134	1.052E-30	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-137	3.958E-24	0.2588	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sb-125	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.529E-23	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

0 Water Dependent Pathways

0	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.133E-23	0.7412
Cs-134	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.052E-30	0.0000
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.958E-24	0.2588
Pu-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sb-125	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.529E-23	1.0000

0*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	2.435E-27	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-134	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-137	2.102E-24	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-238	1.460E-30	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sb-125	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.105E-24	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.435E-27	0.0012
Cs-134	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.102E-24	0.9988
Pu-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.460E-30	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sb-125	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.105E-24	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-134	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-137	3.447E-25	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-238	7.789E-29	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sb-125	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.448E-25	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-134	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.447E-25	0.9998
Pu-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.789E-29	0.0002
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sb-125	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.448E-25	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-134	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-238	2.969E-25	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sb-125	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.969E-25	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Co-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-134	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.969E-25	1.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ru-106	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sb-125	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.969E-25	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

0 Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Co-60	Co-60	1.000E+00	5.795E-22	5.136E-22	4.035E-22	1.734E-22	1.553E-23	3.336E-27	1.105E-37	0.000E+00
0Cs-134	Cs-134	1.000E+00	3.147E-26	2.280E-26	1.196E-26	1.252E-27	1.984E-30	3.139E-40	0.000E+00	0.000E+00
0Cs-137+D	Cs-137+D	1.000E+00	3.874E-27	3.839E-27	3.770E-27	3.539E-27	2.954E-27	1.569E-27	2.573E-28	4.594E-31
0Pu-238	Pu-238	1.840E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0Pu-238	Pu-238	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pu-238	U-234	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pu-238	Th-230	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pu-238	Ra-226+D	1.000E+00	1.062E-36	1.596E-35	1.868E-34	5.019E-33	1.277E-31	5.369E-30	2.864E-28	1.092E-24
Pu-238	Pb-210+D	1.000E+00	0.000E+00	0.000E+00	2.803E-45	2.200E-43	1.513E-41	1.751E-39	2.245E-37	4.527E-33
Pu-238	äDSR(j)		1.062E-36	1.596E-35	1.868E-34	5.019E-33	1.277E-31	5.369E-30	2.864E-28	1.092E-24
0Pu-239	Pu-239	1.000E+00	6.174E-42	6.299E-42	6.552E-42	7.526E-42	1.118E-41	4.471E-41	2.343E-39	2.443E-33
Pu-239	U-235+D	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.401E-45	7.147E-44	1.029E-37
Pu-239	Pa-231	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.605E-45	1.135E-43	6.516E-42	9.642E-37
Pu-239	Ac-227+D	1.000E+00	5.605E-45	8.128E-44	9.193E-43	2.249E-41	4.522E-40	1.118E-38	4.120E-37	7.536E-33
Pu-239	äDSR(j)		6.180E-42	6.380E-42	7.472E-42	3.001E-41	4.634E-40	1.122E-38	4.144E-37	9.980E-33
0Ru-106+D	Ru-106+D	1.000E+00	1.601E-28	1.147E-30	5.880E-35	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0Sb-125+D	Sb-125+D	1.000E+00	9.671E-29	1.073E-30	1.320E-34	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

The DSR includes contributions from associated (half-life ó 180 days) daughters.
0

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

0Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Co-60	*1.132E+15	*1.132E+15	*1.132E+15	*1.132E+15	*1.132E+15	*1.132E+15	*1.132E+15	*1.132E+15
Cs-134	*1.295E+15	*1.295E+15	*1.295E+15	*1.295E+15	*1.295E+15	*1.295E+15	*1.295E+15	*1.295E+15
Cs-137	*8.704E+13	*8.704E+13	*8.704E+13	*8.704E+13	*8.704E+13	*8.704E+13	*8.704E+13	*8.704E+13
Pu-238	*1.712E+13	*1.712E+13	*1.712E+13	*1.712E+13	*1.712E+13	*1.712E+13	*1.712E+13	*1.712E+13
Pu-239	*6.214E+10	*6.214E+10	*6.214E+10	*6.214E+10	*6.214E+10	*6.214E+10	*6.214E+10	*6.214E+10
Ru-106	*3.348E+15	*3.348E+15	*3.348E+15	*3.348E+15	*3.348E+15	*3.348E+15	*3.348E+15	*3.348E+15
Sb-125	*1.033E+15	*1.033E+15	*1.033E+15	*1.033E+15	*1.033E+15	*1.033E+15	*1.033E+15	*1.033E+15

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

0Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Co-60	7.300E-01	0.000E+00	5.795E-22	*1.132E+15	5.795E-22	*1.132E+15
Cs-134	5.300E-01	0.000E+00	3.147E-26	*1.295E+15	3.147E-26	*1.295E+15
Cs-137	1.340E+03	0.000E+00	3.874E-27	*8.704E+13	3.874E-27	*8.704E+13
Pu-238	2.720E-01	1.000E+03	1.092E-24	*1.712E+13	0.000E+00	*1.712E+13
Pu-239	5.500E-01	0.000E+00	0.000E+00	*6.214E+10	0.000E+00	*6.214E+10
Ru-106	5.300E+00	0.000E+00	1.601E-28	*3.348E+15	1.601E-28	*3.348E+15
Sb-125	2.700E+00	0.000E+00	9.671E-29	*1.033E+15	9.671E-29	*1.033E+15

*At specific activity limit

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

0Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Co-60	Co-60	1.000E+00	4.230E-22	3.750E-22	2.946E-22	1.266E-22	1.133E-23	2.435E-27	0.000E+00	0.000E+00
0Cs-134	Cs-134	1.000E+00	1.668E-26	1.208E-26	6.340E-27	6.638E-28	1.052E-30	0.000E+00	0.000E+00	0.000E+00
0Cs-137	Cs-137	1.000E+00	5.191E-24	5.144E-24	5.052E-24	4.742E-24	3.958E-24	2.102E-24	3.447E-25	0.000E+00
0Pu-238	Pu-238	1.840E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pu-238	Pu-238	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pu-238	äDOSE(j)		0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0U-234	Pu-238	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0Th-230	Pu-238	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0Ra-226	Pu-238	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.460E-30	7.789E-29	2.969E-25
0Pb-210	Pu-238	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0Pu-239	Pu-239	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0U-235	Pu-239	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0Pa-231	Pu-239	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0Ac-227	Pu-239	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0Ru-106	Ru-106	1.000E+00	8.487E-28	6.077E-30	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0Sb-125	Sb-125	1.000E+00	2.611E-28	2.897E-30	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

0Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Co-60	Co-60	1.000E+00	7.300E-01	6.395E-01	4.908E-01	1.943E-01	1.377E-02	1.304E-06	4.163E-18	0.000E+00
0Cs-134	Cs-134	1.000E+00	5.300E-01	3.786E-01	1.932E-01	1.835E-02	2.199E-05	1.310E-15	8.408E-45	0.000E+00
0Cs-137	Cs-137	1.000E+00	1.340E+03	1.309E+03	1.250E+03	1.062E+03	6.663E+02	1.305E+02	1.238E+00	1.029E-07
0Pu-238	Pu-238	1.840E-09	5.005E-10	4.963E-10	4.881E-10	4.605E-10	3.899E-10	2.177E-10	4.118E-11	1.213E-13
Pu-238	Pu-238	1.000E+00	2.720E-01	2.697E-01	2.653E-01	2.503E-01	2.119E-01	1.183E-01	2.238E-02	6.591E-05
Pu-238	äS(j):		2.720E-01	2.697E-01	2.653E-01	2.503E-01	2.119E-01	1.183E-01	2.238E-02	6.591E-05
0U-234	Pu-238	1.000E+00	0.000E+00	7.614E-07	2.227E-06	6.798E-06	1.588E-05	2.248E-05	6.807E-06	2.168E-08
0Th-230	Pu-238	1.000E+00	0.000E+00	3.442E-12	3.046E-11	3.192E-10	2.439E-09	1.585E-08	4.138E-08	4.826E-08
0Ra-226	Pu-238	1.000E+00	0.000E+00	4.965E-16	1.315E-14	4.561E-13	1.022E-11	2.025E-10	1.149E-09	1.668E-09
0Pb-210	Pu-238	1.000E+00	0.000E+00	3.835E-18	3.012E-16	3.341E-14	2.008E-12	9.453E-11	8.243E-10	1.310E-09
0Pu-239	Pu-239	1.000E+00	5.500E-01	5.498E-01	5.493E-01	5.475E-01	5.426E-01	5.256E-01	4.800E-01	3.493E-01
0U-235	Pu-239	1.000E+00	0.000E+00	5.370E-10	1.583E-09	4.971E-09	1.265E-08	2.536E-08	2.847E-08	2.087E-08
0Pa-231	Pu-239	1.000E+00	0.000E+00	5.665E-15	4.984E-14	5.114E-13	3.683E-12	1.976E-11	3.520E-11	2.674E-11
0Ac-227	Pu-239	1.000E+00	0.000E+00	5.919E-17	1.515E-15	4.674E-14	7.769E-13	7.240E-12	1.510E-11	1.159E-11
0Ru-106	Ru-106	1.000E+00	5.300E+00	3.741E-02	1.864E-06	1.627E-21	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0Sb-125	Sb-125	1.000E+00	2.700E+00	2.951E-02	3.526E-06	6.576E-20	0.000E+00	0.000E+00	0.000E+00	0.000E+00

THF(i) is the thread fraction of the parent nuclide.
0RESCALC.EXE execution time = 2.01 seconds

Appendix E

Closure Summary

E.1.0 Appendix E: Closure Summary

A land-use restriction will be applied as part of the closure in place alternative for CAU 477. The restriction will be applied to control use and limit access to prevent inadvertent exposure to the lead contaminated soil identified in the muckpile. This contaminant was identified in the shallow subsurface at levels which exceeded the Final Action Level. The completed land-use restriction form and map are included in this appendix.

The following sign will appear on the N-Tunnel gate which controls access to CAU 477:

WARNING

Lead Contaminated Area

Beyond This Point

FFACO Site

CAU 477, Area 12, N-Tunnel Muckpile

CAS 12-06-03, Muckpile

Access to this area is not permitted without

U.S. Government permission

Before working in this area,

Contact Real Estate Services at 295-2528

This site can be closed without further action.

CAU Use Restriction Information

CAU Number/Description: CAU 477, N-Tunnel Muckpile

Applicable CAS Numbers/Descriptions: CAS 12-06-03, N-Tunnel Muckpile

Contact (organization/project): DTRA, N-Tunnel Muckpile

Surveyed Area (UTM, Zone 11, NAD 27, meters):
Southeast Corner: N=4116964.61 S=572289.02
Northeast Corner: N=4117222.45 S=579926.13
Northwest Corner: N=4117382.23 S=571769.27
Southwest Corner: N=4117118.48 S=571599.21
South Center: N=4116965.98 S=571917.67

Survey Date: 9/14/06 **Survey Method (GPS, etc):** GPS

Site Monitoring Requirements: Certify that posting is in place, in tact, and readable

Required Frequency (quarterly, annually?): Annually

If Monitoring Has Started, Indicate last Completion Date:

Use Restrictions

The future use of any land related to this Corrective Action Unit (CAU), as described by the above surveyed location, is restricted from any DTRA, DOE or Air Force activity that may alter or modify the containment control as approved by the state and identified in the CAU Closure Report or other CAU documentation unless appropriate concurrence is obtained in advance.

Comments: The lead concentrations that pose a risk to human health and the environment are in the surface and shallow subsurface soil between 0 and 2 feet below ground surface. Therefore a use restriction will be applied to the muckpile to prevent inadvertent exposure to site workers.

Submitted By: /s/ Signature on file **Date:** 5/3/07

cc with copy of survey map (paper and digital (dgn) formats):
CAU Files (2 copies)

CAU477 Use Restriction Boundary
N-Tunnel Muckpile

N

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